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BALLISTIC MISSILE DEFENSE AND DECEPTIVE BASING: A NEW CALCULUS --ETC(U)
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BALLISTIC MISSILE DEFENSE AND DECEPTIVE BASING:

A New Calculus for the Defense of ICBMs

RAYMOND E. STARSMAN

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BALLISTIC MISSILE DEFENSE AND DECEPTIVE BASING:

A New Calculus for the Defense of ICBMs

by
Colonel Raymond E. Starsman, USA
Senior Research Fellow
Research Directorate

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DEDICATION

To Milton A. Margolis
from whom I learned to ask—WHY?

To Lieutenant General Maxwell R. Thurman
from whom I learned to ask—WHY NOT?

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FOREWORD

I am pleased to introduce this first publication of the NDU Press since I replaced my distinguished predecessor, Lieutenant General Robert G. Gard, Jr., USA.

Over the coming years, National Defense University (NDU) will build upon the fine foundation provided by its first two presidents and by the long history of our teaching institutions, the National War College and the Industrial College of the Armed Forces. A major goal will be to make NDU a recognized "national asset" that contributes significantly at the forefront of thinking on military strategy, employment, mobilization, and deployment. I strongly believe that we should become a repository of expertise and a fountainhead of creative ideas in these essential national security areas and have initiated major steps to achieve that goal.

This monograph typifies the kind of inquiry we will continue to encourage. History is rife with mankind's innovative attempts to overcome seemingly invulnerable instruments of war and deterrence. The continuing debate about the survivability of the US intercontinental ballistic force is another chapter in this saga of weapon versus counterweapon.

In this monograph, Colonel Starsman explores the potential contribution that ballistic missile defenses might make to the survival of deceptively based ICBMs against post-1990 Soviet threats. His microcosmic examination suggests principles of preferential defense and deceptive basing that may have utility beyond specific systems. The author draws on widely available data to suggest their applicability to many current systems as well as to the MX.

Colonel Starsman concludes that we are at an important stage in strategic weaponry and that defense could emerge as a significant contributor to deterrence over the next two decades. This work was begun under the auspices of my predecessor, but its relevance has only been enhanced by the intervening months of increasing national deliberation. The considerations the author develops should assist defense planners and others interested in maintaining US national security.

JOHN S. PUSTAY
Lieutenant General, USAF
President

ABOUT THE AUTHOR

Colonel Raymond E. Starsman, US Army, wrote this monograph while a Senior Research Fellow with the National Defense University and concurrently a student at the National War College. He is a graduate of West Point and holds master's degrees in Aeronautical and Mechanical Engineering from the University of Arizona and the Master of Military Arts and Science degree from the Army Command and General Staff College. His most recent assignments have involved: managing the development of the Army five-year program while in the Office of the Chief of Staff, Army; commanding a HAWK air defense missile battalion in Korea; and directing the Program Cost Analysis Division in the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation. He has published articles and presented papers before the American Society for Quality Control, the Military Operations Research Society, the DOD Cost Symposium and the NATO Defense Research Group. Colonel Starsman is currently serving as Chief, Missiles and Air Defense Systems Division, Office of the Deputy Chief of Staff for Research, Development and Acquisition, Department of the Army.

PREFACE

The purpose of this monograph is to explore the potential contribution of ballistic missile defenses to the survival of deceptively based ICBMs in the face of Soviet threats postulated for the post-1990 period. Implicit in the study is the assumption that the land-based leg of the triad of air-, land-, and sea-based strategic nuclear weapons has continuing utility well into the 21st century.

The Air Force MX ICBM deceptively based in multiple protective structures and the Army Low Altitude Defense System (LoADS) are used for illustrative purposes because these are well defined candidate systems for providing ICBM survivability. However, this monograph is not a paean for a particular weapon system. The principles of preferential defense and deceptive basing have utility beyond specific systems and could be applied to Minuteman, Pershing II, the Ground Launched Cruise Missile, and conventional air defenses as well as MX and other future systems.

The paper is organized in the same sequence followed in analyzing the problem. Chapter 1 discusses the theory of deceptive basing and the enhanced leverage possible with ballistic missile defense (BMD). Chapter 2 develops a qualitative and quantitative range of threats feasible in the post-1990 period. Small threats are constrained by SALT II; larger threats are unconstrained. Chapter 3 describes MX in multiple protective structures as an illustrative baseline for deceptive basing. Chapter 4 describes LoADS as an illustrative baseline for preferential defense. Chapters 3 and 4 conclude with mathematical formulations and resultant tables essential to the analysis but not essential to understanding the thrust of the paper. Expository remarks have been placed in the text to facilitate those readers who may wish to skip the quantitative calculations and go directly to the summary and analysis of alternatives in Chapter 5. Chapter 6 provides a discussion of the advantages and disadvantages of BMD relative to the proliferation of protective shelters as a means of enhancing the survival of ICBMs. The chapter also addresses ABM Treaty considerations and concludes with recommendations for future BMD efforts.

This research would not have been possible without the help and generous cooperation of the MX and BMD Program Managers and their Offices and the OSD, Army, and Air Staffs. Valuable criticism

was received from Bryan Jack, William Winter, and Angeliki Cutchis of the OSD Staff, Captain Gregg Smith and Major Victor Bras of the Air Staff, Dr. Daniel Willard of the Army Secretariat, Jack Kalish and Colonel Harry Ennis of the BMD Program Office, and Dr. William Holley of Duke University, each of whom read and commented upon the monograph in one of its many drafts. I am also indebted to my son, Scott, who prepared the computer programs necessary to convert the abstract equations of Chapters 3 and 4 into useful tables and to Laura Hall for typing and incorporating many changes to the manuscript as it evolved. Finally, I was fortunate to enjoy the capable assistance of George Maerz and Lou Walker, Editors, and Colonel Franklin Margiotta, Director, National Defense University Research Directorate, for reviewing, editing, and bringing this monograph to press.

The illustrative data used in the preparation of this monograph came from widely available, unclassified, previously published works and congressional testimony. I intentionally did not include any classified material so that the monograph might contribute to the public debate on ICBMs, their defense, and their basing. Although the illustrative data are not the same as data available to policy decisionmakers, the exclusive use of open literature permitted me to develop an analogous model which demonstrated the case. Specific sources are documented at the bottom of pertinent figures and tables, as well as by notes at the end of each chapter.

As this has been an independent research, I bear full responsibility for any error of fact or analytical technique. Unless otherwise noted the views, conclusions, and recommendations of the monograph are my own and do not necessarily reflect US Government policy or the policy of any of the organizations or individuals I have acknowledged.

RAYMOND E. STARSMAN
Colonel, USA

Everybody has heard of the curious contest that existed during the Confederate War between the cannon and the iron clads—the one bent on being irresistible, the other on being impenetrable. The consequence was a radical change in the navy of both continents. The projectile and the iron plate fought each other with unexampled persistency, the one increasing in thickness as fast as the other increased in weight. Vessels armed with tremendous guns, and sheltered by their invulnerable coat of mail, went unharmed under the hottest fire. The *Merrimacs*, and *Monitors*, the *Miantonomahs*, the *Weehawkens*, the *Dictators*, the *Dunderbergs*, were thus enabled to discharge their enormous projectiles almost with perfect impunity. They did unto others what they would not allow others to do unto them—a highly immoral principle, though the whole art of "glorious" war is based on it.

Jules Verne

Chapter 1. The Emerging Strategic Environment— A New Framework

The history of conventional warfare is replete with examples of the interaction among technology, tactics, and the continuously shifting balance between offense and defense.[1] In the Civil War, the ironclads with their armored defense were able to defeat their unarmored adversaries, radically altering the conduct of future naval warfare. In World War I, defending machineguns stabilized the front and created the need for a new offensive weapon, the tank, to restore mobility to the battlefield. Today the preeminence of the tank in battle is challenged by antiarmor precision-guided munitions. The side that first grasps the significance of new weapons technology and uses this knowledge to modify tactics and reallocate resources between offense and defense can tilt the probability of winning to its favor.

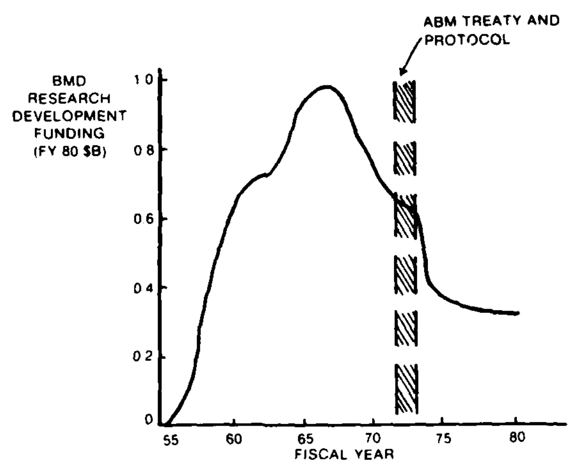
In the strategic nuclear arms arena, offensive weapons have historically been the dominant factor. The perceived ease with which changes in offensive tactics and technology could create cost, complexity, and risk problems for the defense caused US strategic planners to accord ballistic missile defense (BMD) systems a relatively low priority. This general disdain for the defense, coupled with the great

leverage provided the offense by multiple independently targetable reentry vehicles (MIRVs) and the strategic nuclear force doctrine of assured destruction favored in the 1960s,[2] formed the backdrop for the negotiations which resulted in the treaty between the United States and the Soviet Union, signed on 26 May 1972, limiting anti-ballistic missile (ABM) systems.

Codified into law, the 1972 ABM limitation treaty and 1974 protocol tended to focus even further the thinking of US strategic planners on the offense with the result that BMD research and development efforts have decreased to the lowest levels in over 20 years, from $.6 billion in 1960 to $.3 billion in 1980 as shown in Figure 1-1.[3] In the debate on how the United States should best counter the growing threat to our Minuteman forces, the preponderance of strategic thinking has concentrated on the modernization and basing of the offense. Consideration of active defenses continued to have low priority.[4]

FIGURE 1-1

BMD RESEARCH AND DEVELOPMENT FUNDING[3]
(FY 80 Dollars in Billions)



Adopted from E. C. Aldridge, Jr., and Robert L. Maust, Jr., "SALT Implications of BMD Options," Symposium Paper, Harvard University Center for Science and International Affairs, November 1979.

To counter the widely acknowledged, growing Soviet threat to US landbased Minuteman intercontinental ballistic missiles (ICBMs),[5] President Carter in August 1979 announced plans to deploy the MX ICBM in a basing mode utilizing multiple protective structures (MPS). The 92-inch diameter MX missile is capable of delivering a payload probably comprising 10 Mark 12A MIRVs. The MX will, when deployed, represent a significant improvement to our land-based ICBM forces.

Perhaps even more significant than the increased capability of the MX missile is its planned, highly survivable, basing mode. By providing more hardened shelters than there are missiles and randomly moving the missiles among the shelters, actual ICBM locations are unknown to an attacker. To insure destruction of the MX force, the offense must expend enough warheads to strike every shelter. In effect, MPS basing has the potential to increase defensive leverage by absorbing reentry vehicles (RVs) on multiple targets, thus neutralizing for the first time the improved offensive leverage provided by MIRVs in the early 1970s. Conceptually, MPS basing can preclude an attacker from destroying more ICBMs than he expends, provided the defense constructs at least as many protective shelters per defended ICBM as there are MIRVs per attacking ICBM.

More than changing a single variable, the emerging concept of MPS basing may have altered the fundamental equation within which strategic arms planning is conducted. The tactical, technical, and cost leverages which have historically resided with the strategic offense may well have shifted to the passive defense resultant from MPS basing.

With the selection by the President of MPS as the preferred basing mode for MX, new interest has been aroused in ballistic missile defense. Active defense employed in conjunction with MPS basing offers the promise of multiplying the leverage achieved by undefended shelters alone. For example, the offense must expend at least one RV for every properly spaced protective shelter to insure that an MPS-based ICBM is destroyed. If the defense could selectively intercept the first RV correctly targeted against the ICBM, the attacker would be required to expend a second salvo of RVs on each shelter to insure destruction of the ICBM.[6] Thus, active defense with a single interceptor could increase MPS leverage by a factor of two. Each additional interceptor capable of preferentially engaging only the RVs which threaten the concealed ICBM would theoretically require the offense to expend additional salvos of RVs against all shelters.

The promise of additional leverage provided by an active defense would be particularly useful in the event of SALT failure. Other potential benefits of an active defense requiring further analysis include fiscal economies; reduced land, water, and energy requirements; responsiveness to threat growth; and the provision of an option for the President other than launching ICBMs upon warning or accepting loss of the ICBM force to a Soviet attack.[7] The possibility that the United States could absorb a Soviet first strike and be left with its ICBM forces still largely intact would have a deterrent effect. In fact, if the leverage advantage resides with the defense, an attack would serve to disarm the attacker, leaving the post-attack defense in an improved position relative to the offense.

The concept of "the superiority of the defense over attack . . ." expounded by Clausewitz has been a principle of conventional warfare for over 150 years.[8] Overcoming the technical and tactical hurdles to an active ballistic missile defense and achieving theoretically possible leverages would apply the principle of the ascendency of defense to strategic planning, signaling a shift in the conduct, nature, and doctrine of strategic warfare eclipsing even those changes wrought by the MIRV.

The merits of the defense in strategic planning will be tested in this paper by exploring the cost and survivability of an illustrative MPS-based MX system, both defended and undefended, against a range of post-1990 threats. Analyses, conclusions, and recommendations will be focused more on military rather than political issues. However, the impact of SALT II constraints and the scheduled 1982 review of the ABM treaty will be addressed.

Chapter 1. ENDNOTES

1. "Looking back, it is clear that certain technologies . . . had a crucial impact on the style and pace of military operations, and more specifically on the nature of the duel between offense and defense." From Richard Burt, "New Weapons Technologies: Debate and Directions," *Adelphi Papers*, No. 126 (Summer 1976), p. 2.

2. "*In his last report* to the Congress as Secretary of Defense, in January 1968, Clark Clifford stressed the point of view that in the strategic balance defense was secondary: 'We remain convinced . . . we should continue to give primary priority in the allocation of available resources to the primary objective of our strategic forces, namely assured destruction.' " From Henry Kissinger, *White House Years*, (Boston: Little, Brown & Company, 1979), p. 205.

3. BMD funding data is an update of historical data contained in: E. C. Aldridge, Jr. and Robert L. Maust, Jr., "*SALT Implications of BMD Options*," Symposium Paper, Harvard University Center for Science and International Affairs, November 1979.

4. ". . . the Anti-Ballistic Missile (ABM) Treaty of 1972 and the 1974 Protocol restrict the deployment of ABM systems in order to prevent a futile damage-limiting competition. Our current programs for active defense reflect these constraints and the emphasis we place on offensive forces for deterrence." US Department of Defense, *Annual Report Fiscal Year 1981*, 29 January 1980, p. 136.

5. "It is quite conceivable, at some point in the early to mid-1980s, that the Soviets—with a first strike—could eliminate the bulk of our ICBM silos and still retain a large number of warheads in reserve." US Department of Defense, *Annual Report Fiscal Year 1980*, 25 January 1979, p. 15.

6. It is assumed that there would be no realistic shoot-look-shoot opportunity for the attacker. That is, the attacker could not strike all shelters, make a damage assessment, retarget, and launch a second salvo against surviving shelters only. To preclude the defense from launching its surviving ICBMs after the initial attack, other attacking salvos would have to fall either concurrently or immediately following the initial attack.

7. The policy of the Carter administration on launch on warning or attack has been clearly stated: ". . . it is one thing . . . to have an operational capability to launch nuclear weapons, with warning or under attack. It is quite another matter to be obliged to launch them simply in order to avoid losing them to the attacker. The latter posture, with its vulnerability to accidents and false alarms, and still more with its premium on hasty action rather than deliberation and control, is unacceptable to the United States." US Department of Defense, *Annual Report Fiscal Year 1981*, 29 January 1980, p. 88.

Gerald Ford has expressed similar views, ". . . we need to modify our strategic employment doctrine. No president should be forced to choose between the massive destruction of the Soviet Union or surrender. That is an intolerable burden. It is an intolerable choice." Gerald Ford as reported in "Gerald Ford Takes His Stand on SALT," *Washington Post*, 26 September 1979, p. A25.

8. "As we shall show, defense is a stronger form of fighting than attack. . . . I

am convinced that the superiority of the defensive (if rightly understood) is very great, far greater than appears at first sight. It is this which explains without any inconsistency most periods of inaction that occur in war." From Carl Von Clausewitz. *On War*, ed. and transl., by Michael Howard and Peter Paret (Princeton: Princeton University Press, 1976), p. 84.

Chapter 2.
Exploring the Threat—
The Numbers Game

The driving consideration in assessing the capability and desirability of defending US land-based ICBMs is the projected threat. A range of threats, with qualitative and quantitative variety, will be postulated in this chapter to represent the post-1990 environment in which US MPS-based ICBMs must survive.

Soviet intentions, the outcome of current and future strategic arms negotiations, the international political climate, actions of third countries, technological developments, and national choices on both sides will ultimately shape the real threat. While the projected threat must be sufficiently broad to insure that it encompasses the real threat, it must also be sufficiently focused to insure that reasonableness, feasibility, and utility are preserved.

The principal post-1990 threat to US MPS-based ICBMs is assumed to be Soviet MIRVed ICBMs, because other Soviet strategic systems are less efficient at attacking the complex, time sensitive, hardened, point target presented by MPS-based ICBMs. Several important, but reasonable, assumptions underlie this conclusion:

- Bombers and cruise missiles are too slow and the warning time they provide too great to be used preemptively against ICBMs. With warning time measured in hours, the defense would have ample time to react to the relatively slow moving, detectable, and unambiguous airbreathing attack and either conventionally engage the attackers or launch threatened strategic weapons before the attack on them could be consummated.

- Single-warhead ICBMs are less efficient than MIRVed ICBMs in an attack on multiple protective structures since, due to less than perfect warhead reliability and the proliferation of large numbers of hardened shelters, many more ICBMs would be expended in the attack than would be destroyed, leaving the offense in a weaker relative position following the attack than at its onset.

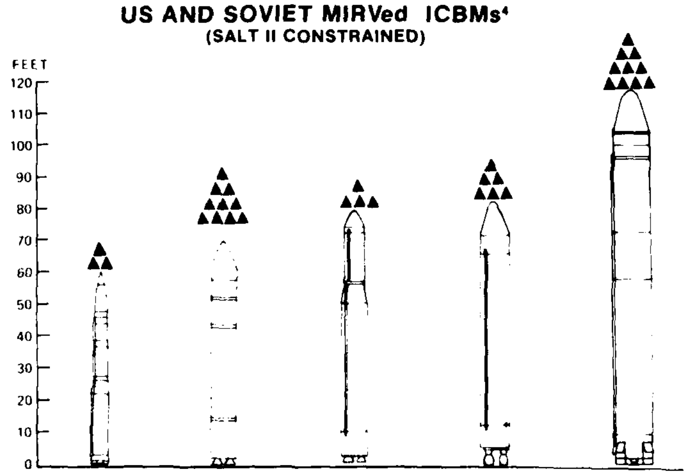
- Current Soviet submarine-launched ballistic missiles (SLBMs) lack the combination of yield, number of warheads, accuracy, reliability, and responsive command, control, and communications necessary to execute the complex and time-sensitive attack required for MPS-based ICBMs.[1] Qualitative improvements can be expected by the 1990s; however, there is some question that even improved SLBMs will have the requisite combination of characteristics to attack an MPS-based ICBM deployment efficiently.[2] Two threatening elements would, nonetheless, be introduced by improved SLBMs: (1) they could be targeted against US facilities (other than ICBMs) previously targeted by Soviet MIRVed ICBMs, freeing the entire Soviet MIRVed ICBM force for use against US land-based ICBMs, and (2) the mere existence of improved, hard-target capable SLBMs could complicate the warning, passive defense, and active defense equations for MPS-based ICBMs.

In the final analysis, it is principally MIRVed ICBMs which have the requisite combination of accuracy, yield, speed, responsiveness, reliability, and warhead numbers to engage efficiently the complex target presented by MPS-based ICBMs. Soviet MIRVed ICBMs are the threat to be explored in detail for this analysis. Improved SLBMs are addressed implicitly by considering that the entire Soviet MIRVed ICBM force is free to threaten US land-based ICBMs in the post-1990 period.

The Soviets are currently replacing their older single warhead SS-9 and SS-11 ICBMs with the fourth generation MIRVed SS-17, SS-18, and SS-19[3] missiles. These are pictured schematically in Figure 2-1 in comparison to the United States Minuteman III and proposed MX MIRVed ICBMs.[4] As of January 1980 there were more than 200 SS-18s deployed in converted SS-9 silos and 350 SS-17 and SS-19 missiles in converted SS-11 silos.[5]

FIGURE 2-1

US AND SOVIET MIRVed ICBMs[4]
(SALT II CONSTRAINED)



ICBM	MM III	MX	SS 17	SS 19	SS 18
INITIAL OPERATING CAPABILITY	1970	1986 PROGRAMMED	1975	1975	1974
PROPULSION					
STAGES	3	4	2	2	2
PROPELLANT	SOLID	SOLID	LIQUID	LIQUID	LIQUID
LAUNCH	HOT	HOT	COLD	HOT	COLD
RANGE (NM)	7 000	6 000	5 000	5 000	5 000

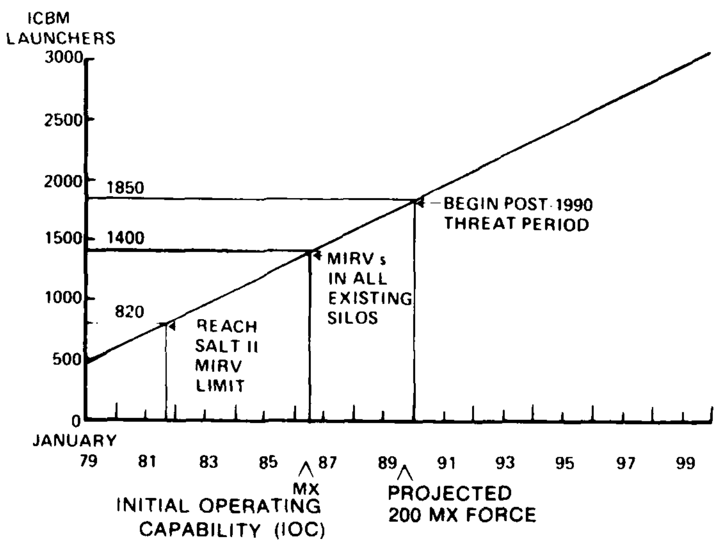
Sources for composite figure: Minuteman III and Soviet ICBM dimensions, propulsion, and range are drawn from Jane's Weapon Systems, 1979-80 ed., pp. 6-17. MX characteristics drawn from Pepe Lobo, "Missile Experimental," *TRW Systems and Energy Magazine,* fall 1979, pp. 10-12.

If the Soviets continue to deploy MIRVed ICBMs at the current combined rate of approximately 125 missiles per year[6] they will reach the SALT II constraint of 820 MIRVed ICBM launchers before the end of 1981 as shown in Figure 2-2. In the absence of or in violation of SALT limits, the Soviets, by simply continuing missile deployment at the current rate, could fill all of their existing silos with fourth generation MIRVed ICBMs in 1986, the target year for MX initial operating capability (IOC). By 1990, without accelerating their current rate of deployment, the Soviets could (by constructing additional silos, using mobile launchers, or re-using silos after a cold launch) confront the projected US force of 200 MX ICBMs with 1,850 SS-17, SS-18, and SS-19 ICBMs.

FIGURE 2-2

SOVIET POTENTIAL TO DEPLOY MIRVed ICBM[6] LAUNCHERS

(125 ICBM LAUNCHERS DEPLOYED PER YEAR)

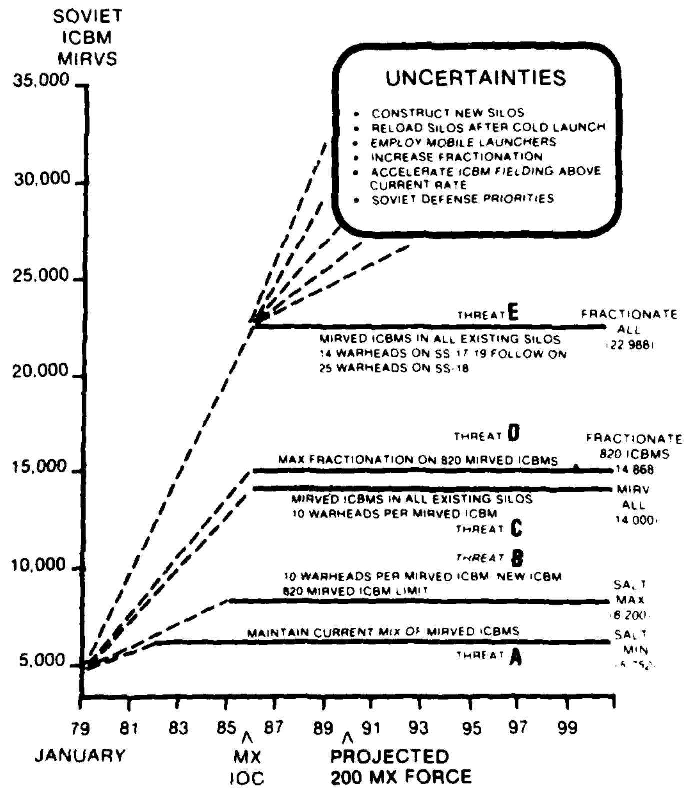


Source for projection chart: DOD Annual Report: FY 1981, p. 79.

The most menacing dimension of the threat, however, is not launchers *per se* but the associated number of warheads with hard-target kill potential. As can be seen in Figure 2-3, the Soviets have great flexibility in selecting the quantities of warheads to be placed on

FIGURE 2-3

POTENTIAL THREAT TO US ICBMs[7]
(125 ICBM LAUNCHERS DEPLOYED PER YEAR)



Sources for projection data: Congressional Budget Office Issue Paper for FY 1980, "The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications," June 1979, pp. 130-135; and Department of Defense Annual Report: FY 1981, pp. 77-81.

their ICBMs. Feasible Soviet ICBM warhead deployments ranging from under 6,000 to over 20,000 can be logically postulated for the post-1990 period.

Existing ICBM warhead numbers are limited by SALT II. The combination of Soviet ICBMs producing a SALT-constrained threat containing 5,752 MIRVs when extended to 1990 with no further quantity or quality improvements provides the minimum threat to be considered in this paper (Threat A). A threat this small in 1990 is not likely without limitations beyond those envisioned by the tabled SALT II.

Development of a new MIRVed light ICBM bearing 10 warheads could generate a SALT II-constrained threat of 8,200 warheads (Threat B). This threat, from a notional SS-17/19 follow-on ICBM, compares with a notional US force of 350 Minuteman III and 200 MX ICBMs. These US forces do not reach the 820 limit on MIRVed ICBMs because the United States maintains a balanced triad with 3/4 of the allowable warheads and 2/3 of throw-weight carried by the sea and air-breathing legs. The Soviets, on the other hand, have placed greater emphasis on land-based ICBMs.[8]

The two post-1990 threats developed thus far are based on the Soviets abiding by SALT II limits for 5 years beyond the end of the currently unratified treaty. A number of feasible scenarios can be developed for cases in which SALT II does not enter into force, is not extended beyond 1985, or is abrogated. Three such scenarios lead to threats of 14,000 MIRVs (Threat C) for a case in which the Soviets deploy ICBMs bearing 10 MIRVs in all 1,400 of their currently existing silos; 14,868 MIRVs each (Threat D) for a case in which the Soviets improve accuracy and increase the number of MIRVs (fractionate) to 14 for the notional SS-17/19 follow-on and to 25 for the heavy SS-18 while staying within the 820 overall MIRVed ICBM launcher constraint; and 22,988 MIRVs (Threat E) for the case in which all 1,400 current silos are filled with ICBMs bearing increased fractionation warheads with improved accuracy. In the last two cases, it is assumed that by 1990 the Soviets could achieve increased accuracies.

The two SALT-constrained and three SALT-failure scenarios developed thus far offer sufficient diversity of threat against which to measure the potential contribution of BMD in protecting MPS-based ICBMs. These threats are used as a baseline for the remainder of the paper.

Chapter 2. ENDNOTES

1. Admiral John M. Lee, "An Opening 'window' for Arms Control." *Foreign Affairs* Vol. 58, No. 1 (Fall 1979), p. 125.

2. The Soviets, in an effort to improve the hard-target kill potential of their SLBMs, would face the same disadvantages enumerated for the United States below, with the exception that Soviet Global-Positioning System satellites would probably not be attacked if the Soviets launched preemptively:

> The demerits even of such an upgraded SLBM force as opposed to a survivable ICBM force are the following: (1) relatively unreliable C³—the importance of this issue depends upon the kind of strategic use options that one envisages; (2) relative *inflexibility*—an SSBN that launches a few SLBMs betrays its position; (3) relative unavailability and vulnerability—part of the SSBN force will not be "on station," and an important fraction of that force could be caught in port; (4) relative unreliability of CEP upgrade "fixes"—GPS satellites can be attacked or jammed (not easily, admittedly because of their high orbital planes), and radiation sensing for terminal guidance likewise can be jammed or decoyed.

Leon Goure, William G. Hyland, and Colin S. Gray, *The Emerging Strategic Environment: Implications for Ballistic Missile Defense.* (Cambridge, Mass.: Institute for Foreign Policy Analysis, December 1979), p. 64. Also see: Congressional Budget Office, *The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications,* Budget Issue Paper for Fiscal Year 1980, June 1979, p. 22.

3. These are US designations for the Soviet RS-16, RS-20, and RS-18 ICBMs respectively. The more familiar US designations are used throughout the paper.

4. Sources for Figure 2-1 are:
   a. Minuteman III and Soviet ICBM Dimensions, Propulsion, and Range are drawn from: *Jane's Weapon System,* 1979-80 ed., pp. 6-17.
   b. MX characteristics are drawn from: Pepe Lobo, "Missile Experimental," *TRW Systems and Energy Magazine,* fall 1979, pp. 10-12.

5. US Department of Defense, *Annual Report: Fiscal Year 1981,* p. 79.

6. Ibid. p. 79.

7. Sources for Figure 2-3: US Congressional Budget Office, *The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications,* Budget Issue Paper for Fiscal Year 1980, June 1979, p. 133, and Department of Defense Annual Report: FY 1981, pp. 77-81.

Defense Annual Report: FY 1981, pp. 77-81.

8. For contrasting analyses of comparative strategic forces see: US Department of Defense, *Annual Report: Fiscal Year 1981*, 29 January 1980, p. 89; and Paul H. Nitze, James E. Dougherty, and Frances X. Kane, *The Fateful Ends and Shades of SALT*. (New York: Crane, Russak and Company, Inc., 1979), pp. 37-89.

Chapter 3. Multiple Protective Structures (MPS)— The New Math

Survivability of deployed weapon systems can be enhanced through the use of passive and active defensive measures. In general, passive defenses include concealment as to intent, location, and capability, camouflage, site hardening, proliferation, dispersion, mobility, and physical security. Active defenses involve the blunting of attacking forces through direct physical engagement. The combination of air-, land-, and sea-launched strategic weapons in a triad is a form of passive defense as it provides a hedge against defeat of one or two of its legs and enormously complicates the task of the offense. Concealment of US intention and capability to launch strategic weapons upon warning of attack is also a passive defense measure as are the proliferation, dispersion, and hardening of ICBM launch points.

Basing modes recently explored by DOD for the MX ICBM include trenches, rails, dispersed aircraft, and proliferation of shelters. Each of these modes combines one or more of the passive defense measures above and each offers particular advantages and disadvantages. The horizontal multiple protective structure (MPS) basing mode provides the illustrative baseline for this report against which the potential contribution of active defenses will be measured.

The DOD program for MPS basing of MX has undergone numerous refinements as the concept has matured. The current MX operating concept[1] calls for 200 ICBMs deployed in a field of 4,600 horizontal protective shelters. In this concept, the ICBMs are made mobile by a transporter which carries the missile and a mobile launcher together in a launch canister. Figure 3-1 shows the general characteristics of the separate transporter and mobile launcher. Each transporter operates along a road connecting 23 hardened shelters spaced at 5,200 foot intervals to reduce the possibility that a single high-yield warhead could destroy more than one shelter. Figure 3-2 depicts the transporter, launcher, shelter concept. The stock fence shown in the figure encloses a 2.5 acre area. The barriers shown at one end of each road are to aid in verification by constraining any missile from leaving its associated cluster of shelters.

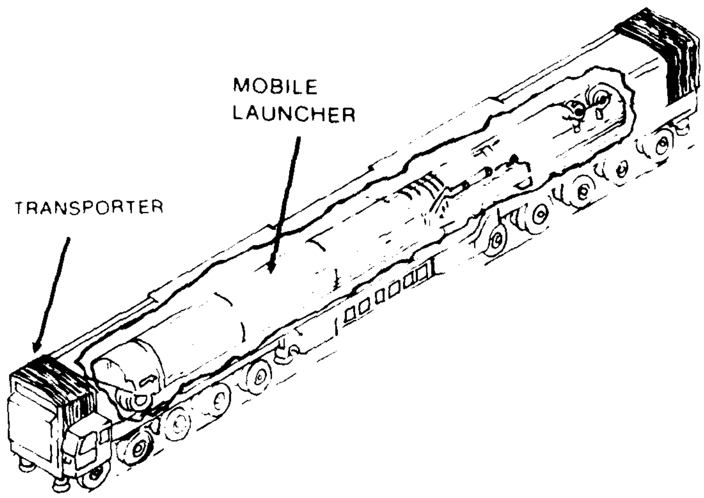
Location uncertainty is preserved by periodic movement of the missile among its associated shelters. The transporter visits all shelters during periodic movement. Since the transporter conceals the missile and launcher internally it is not possible for an observer to know if or when the missile and launcher have been deposited in a shelter. As an additional precaution, the transporter is capable of dashing from the road to a shelter and depositing its missile during Soviet missile flight times; thus, permitting continuous movement of the transporter with missile, if desired.

The official 10-year life cycle cost of the baseline system is estimated by the Air Force to be $40.2 billion in constant FY 80 dollars. Of this amount, $7.6 billion is for research and development, $26.2 billion is for investment including construction of shelters and missile procurement, and $6.4 billion is to operate the system during 3½ years of deployment and for 10 years following attainment of full operating capability. At the margin, the incremental 10-year life cycle cost in constant FY 80 dollars for a missile is $32.27 million and for a protective shelter $3.32 million.

The leverage created for the defense by MPS basing can be described using two examples. Consider, first, a hypothetical case without MPS basing. Opposing countries have 1,000 ICBMs with 10 warheads each or 10,000 warheads. If the systems are 100 percent

FIGURE 3-1

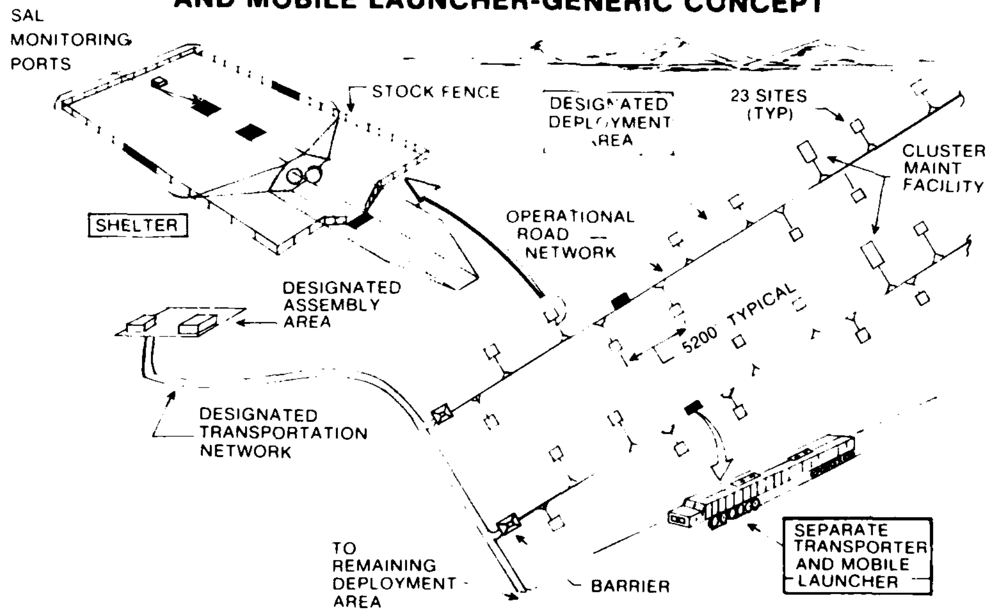
SEPARATE TRANSPORTER AND MOBILE LAUNCHER



GENERAL CHARACTERISTICS	LAUNCHER	TRANSPORTER
WEIGHT (KIPS)		
LOADED	500	1250
EMPTY	—	750
HEIGHT (FT.)	9.7	26
WIDTH (FT.)	9.7	18
LENGTH (FT.)	155	180
TREAD WIDTH (FT.)	4.7	16

FIGURE 3-2

HORIZONTAL SHELTER-SEPARATE TRANSPORTER AND MOBILE LAUNCHER-GENERIC CONCEPT



reliable and effective, the side to attack first can totally destroy the opposing force with only 1,000 warheads, leaving 9,000 warheads in reserve to intimidate the now exposed opponent. This is an unstable situation which rewards the side to strike first. Now consider the case where both sides employ MPS basing by constructing 20 shelters for each of their 1,000 ICBMs. The side to attack first would have to use all 1,000 ICBMs with 10,000 warheads against a target complex of 20,000 identical shelters. The outcome of this second example is that the attacker has disarmed himself while the defender has half his force (or 5,000 warheads) remaining. This is clearly a situation in which the incentive for either side to attack has been removed.

How would the concept of MPS basing work for the threats postulated in Chapter 2 and how much would MX deployments to meet these threats cost? Note: *Before proceeding with the analysis required to answer these questions, those readers not interested in the numerical detail may wish to skip directly to Chapter 4 to read about active defense and then go to Chapter 5 which provides a summary, graphical display, and analysis of the undefended and defended cases developed in Chapters 3 and 4.*

The post-1990 Soviet threat to US ICBMs was estimated as shown in Figure 2-3 to be within the warhead totals below:

Threat A	Threat B	Threat C
SALT (MIN)	*SALT (MAX)*	*MIRV-ALL*
5,752	8,200	14,000

Threat D	Threat E
FRACTIONATE-820	*FRACTIONATE-ALL*
14,868	22,988

If it is assumed that: (1) the Soviets dedicate two ICBM reentry vehicles to each of the hardened Minuteman and Titan silos to insure their destruction, (2) these silos have been reduced in quantity by the United States, to conform to the SALT II MIRV constraint, on a one for one exchange as the 200 MX ICBMs are deployed, and (3) all other targets within the United States can be attacked by improved Soviet SLBMs and bombers, then the number of ICBM MIRVs available to attack the MX field would be the totals above less 1,708 RVs consumed by Minuteman and Titan,[2] or:

Threat A	Threat B	Threat C
SALT (MIN)	*SALT (MAX)*	*MIRV-ALL*
4,044	6,492	12,292

Threat D	Threat E
FRACTIONATE-820	*FRACTIONATE-ALL*
13,160	21,280

Of course, not all the warheads available to the Soviets will successfully destroy their assigned targets. The probability of actually damaging ICBMs hidden in fields of multiple protective shelters would be dependent on several variables. First the RVs would have to be *reliable*. *Reliability (also called probability of arrival)* is the product of the probabilities of the events below:

- ICBM, warheads, and tactical communications are operational upon receipt of the launch command
- Launch is successful
- Powered phase of flight is completed
- RVs deploy properly
- RVs penetrate to intended target
- Warhead detonates

It is difficult to extrapolate wartime reliability from peacetime test firings. In wartime, hundreds of ICBMs will be fired within seconds in an untested polar trajectory by tactical crews under combat conditions. A reliability estimate of .85 has been used in other analyses.[3] If each of the six events above had a probability of success between .97 and .98 the overall system reliability would be about .85. This estimate appears reasonable and will be used for the purposes of this report.

In addition to reliability, warheads would have to have a sufficient combination of yield and accuracy to overcome the hardness of the target protective shelter. This is called warhead effectiveness or kill *probability (PK). For a horizontal protective structure able to with*stand 600 PSI of blast over-pressure,[4] a PK value ranging from .83 to .95 for Threats A through E would be required.

The damage expectancy (DE) is the probability that a given RV will be both reliable and effective.

$$DE = REL \times PK$$

Based on the reliabilities and kill probabilities above, the damage expectancy for each of the five threats is provided below in Table 3-1.

TABLE 3-1. DAMAGE EXPECTANCY TO PROTECTIVE SHELTERS

	Threat				
	A	*B*	*C*	*D*	*E*
DE	.81	.73	.71	.77	.77

The number of ICBMs in an MPS deployment that would be expected to survive an attack can be calculated using the expression below provided the number of shelters is at least as great as the number of attacking RVs:

$$ICBM_s = ICBM_d \times \left(1 - \frac{RV \times DE}{PS}\right) \qquad (3\text{-}1)$$

Where:
$ICBM_s$ = Surviving ICBMs
$ICMB_d$ = Deployed ICBMs
DE = Damage expectancy
RV = RVs available to attack the MPS deployment
PS = Quantity of protective shelters

If the US does not launch on warning, the number of surviving MX ICBMs after a Threat A strike would be:

$$ICBM_s = 200 \times \left(1 - \frac{4044 \times .81}{4600}\right)$$

$$ICBM_s = 58$$

In this example the Soviets would have launched 4,044 of their MIRVs to destroy 1,420 US MIRVs, leaving 580 MIRVs in the US MX arsenal while retaining no ICBM MIRVs in theirs, a decidedly disadvantageous attack.

If the Soviets, still within SALT II limits, MIRVed 820 ICBMs (Threat B) they would have 6,492 RVs available to attack the US baseline MPS deployed ICBMs. If the Soviet launched 4,600 RVs keeping 1,892 in reserve the outcome would be:

$$ICBM_s = 200 \times (1 - \frac{4600 \times .73}{4600})$$

$$ICBM_s = 54$$

In this example the Soviets expend 4,600 RVs to destroy 1,460 US RVs, leaving 540 RVs in the US facing 1,892 Soviet RVs. This outcome favors the Soviets who retain their three-to-one edge in MIRVs but at a lower level in absolute terms. Soviet postattack analysis might reveal which shelters were not destroyed, effectively reducing the size of the MPS deployment. To avoid this outcome, the US could respond to increased Soviet fractionation by increasing the number of shelters while holding the number of deployed ICBMs constant. The number of shelters required to provide a specified number of surviving ICBMs for a given threat can be found by solving equation (3-1) for shelters:

$$PS = \frac{DE \times RV \times ICBM_d}{ICBM_d - ICBM_s}$$

For illustration, the number of shelters required for half the MPS-based ICBMs to survive a Threat B attack is calculated below:

$$PS = \frac{(.73) \times (6{,}492) \times (200)}{200-100}$$

$$PS = 9{,}478$$

The results of this calculation, when applied across a range of surviv-

TABLE 3-2. CASE 1. SHELTERS REQUIRED (200 MX ICBMs Deployed-No BMD)

Surviving ICBMs	Threat* A	Threat* B	Threat* C	Threat* D	Threat* E
	Required Shelters				
5	3,360	4,861	8,951	10,393	16,806
25	3,744	5,416	9,974	11,581	18,726
50	4,368	6,319	11,636	13,511	21,847
75	5,241	7,583	13,964	16,213	26,217
100	6,551	9,478	17,455	20,266	32,771

* RVs available to attack MX based on assumption that each of 854 Minuteman and Titan missiles remaining after one-for-one exchange for 200 deployed MX missiles would be targeted by two Soviet RVs.

ing ICBMs and threats, are provided in Table 3-2. This is the first of four deployment cases to be considered in this paper. In CASE 1, *Undefended Baseline MX,* the number of deployed ICBMs is held constant at 200 while protective shelters vary in number to absorb various threats and still provide a specified level of surviving ICBMs. In Table 3-2, for example, 4,368 shelters would be required, on the average, to provide 50 surviving ICBMs if attacked by Threat A.

The cost for marginal changes to the baseline MX deployment may be expressed:

$$COST_1 = COST_{f1} + (ICBM_d \times C_m) + (PS \times C_{ps}) \qquad (3\text{-}3)$$

Where: $COST_1$ = Cost of variant MX/MPS deployment

$Cost_{f1}$ = Fixed cost for MX/MPS deployment ($18,474 M)[5]

$ICBM_d$ = Number of deployed MX missiles.

C_m = Variable cost to procure and operate missiles ($32.27M)

PS = Number of protective structures

C_{ps} = Variable cost to construct and operate protective structures ($3.32M)

Equation (3-3) is a linear approximation which neglects the learning phenomenon. The equation will be most accurate for deployments

TABLE 3-3. CASE 1. TEN-YEAR LIFE CYCLE COST (200 MX ICBMs Deployed-No BMD)

			Threat		
Surviving ICBMs	*A*	*B*	*C*	*D*	*E*
	FY 80 Dollars in Billions				
5	36.1	41.1	54.6	59.4	80.7
25	37.4	42.9	58.0	63.4	87.1
50	39.4	45.9	63.6	69.8	97.5
75	42.3	50.1	71.3	78.8	112.0
100	46.7	56.4	82.9	92.2	133.7

near the baseline. The costs calculated using equation (3-3) for the preceding CASE 1 MX deployments are provided in Table 3-3. For example, the cost to provide 50 surviving ICBMs if attacked by Threat A, while holding deployed ICBMs constant at 200 is $39.4 billion.

In the face of threat levels exceeding the provisions of SALT II, it is unlikely that the US would either unilaterally constrain itself to 200 MPS-based ICBMs or draw down Minuteman forces. Equation (3-2) when combined with equation (3-3) can be used to optimize the mix of ICBMs and shelters while minimizing cost and producing the required number of surviving ICBMs.

Solving equation (3-1) for $ICBM_d$, substituting this expression into equation (3-3) and differentiating $COST_t$ with respect to PS, to find the expression for optimizing shelters yields:

$$PS = DE \times RV + \sqrt{\frac{DE \times RV \times C_m \times ICBM_s}{C_{ps}}} \qquad (3\text{-}4)$$

Substituting equation (3-2) for PS into equation (3-3) and differentiating with respect to $ICBM_d$ to find the expression for optimizing deployed ICBMs yields:

$$ICBM_d = ICBM_s + \sqrt{\frac{DE \times RV \times C_{ps} \times ICBM_s}{C_m}} \qquad (3\text{-}5)$$

Substituting equations (3-4) and (3-5) back into (3-3) yields an expression for optimizing the mix of shelters and ICBMs to maximize surviving ICBMs for various threats at minimum cost:

$$COST_t = COST_{f1} + (\sqrt{C_m \times ICBM_s} + \sqrt{C_{ps} \times DE \times RV})^2 \qquad (3\text{-}6)$$

The minimum cost combination of ICBMs and shelters required to insure specified levels of survivors is provided in Table 3-4. This is CASE 2, *Undefended Optimized MX/MPS Mix*. Both CASE 1 and CASE 2 are undefended. CASE 2 differs from CASE 1 in that deployed ICBMs are not held constant at 200, rather they vary as required to minimize the cost of preserving the specified level of surviving ICBMs. The costs to acquire, deploy, and operate for 10 years the MX forces shown in Table 3-4 are displayed in Table 3-5. Note that the costs shown in Table 3-5 are, in every case, lower than the costs shown in Table 3-3.

TABLE 3-4. CASE 2. SHELTERS AND UNDEFENDED ICBMs (Optimal Mix)

	Threat*									
	A		B		C		D		E	
Surviving ICBMs	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$
5	3,675	46	5,219	54	9,379	72	10,835	77	17,278	97
25	4,168	117	5,812	136	10,184	175	11,702	186	18,381	230
50	4,537	180	6,257	206	10,787	262	12,352	278	19,208	340
75	4,821	234	6,598	266	11,250	334	12,851	355	19,842	431
100	5,060	284	6,885	321	11,640	400	13,272	423	20,376	511

Note: PS=Number of protective shelters and $ICBM_d$ =Number of ICBMs deployed.

* RVs available to attack MX remain the same as in Table 3-1 in order to facilitate comparison between tables. In actuality, for the last three threats which are unconstrained by SALT II, the United States could hold Minuteman at current levels thereby diverting 400 additional attacking RVs from MPS deployment. The error introduced by this convention tends to overstate slightly the threat available to attack MX.

TABLE 3-5. CASE 2. TEN-YEAR LIFE CYCLE COST (Optimal Mix-Undefended)

	Threat				
Surviving ICBMs	A	B	C	D	E
	FY 80 Dollars in Billions				
5	32.2	37.6	51.9	56.9	79.0
25	36.1	42.1	57.9	63.3	86.9
50	39.3	45.9	62.7	68.5	93.2
75	42.0	49.0	66.6	72.6	98.2
100	44.4	51.7	70.0	76.2	102.6

Tables 3-2 through 3-5 provide a range of MPS-based MX deployments and associated costs required to survive the post-1990 threats projected in Chapter 2. These data and the two cases developed will serve as the baseline for the undefended case against which the potential contribution of ballistic missile defense (BMD) will be measured in Chapter 4. An analysis and graphical comparison of the defended and undefended cases is provided in Chapter 5.

Chapter 3. ENDNOTES

1. The MX concept is drawn from a statement by William J. Perry, Under Secretary of Defense for Research and Engineering, before the Subcommittee on Defense of the House Appropriations Committee, 15 May 1980.

2. William J. Perry, Under Secretary of Defense for Research and Engineering, has indicated,

> ". . . we'll probably take Minuteman out on a one-to-one basis as MX comes in. As we see it, the Soviets would have to attack Minuteman on a two-to-one basis in RVs and MX on a one-to-one basis (per shelter) to destroy our ICBMs."

See David R. Griffiths, "MX Flexibility Allows Doubling Shelters," *Aviation Week and Space Technology,* 17 September 1979, p. 16.

3. Reliability of .85 was the basis for calculations in US Congressional Budget Office, *The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications,* Budget Issue Paper for Fiscal Year 1980, June 1979, p. 20, which references Congressman Thomas A. Downey, "How to Avoid Monad and Disaster," *Foreign Policy,* Fall 1976, pp. 180-81.

4. "The shelters themselves will be hardened only to 600 psi . . . ." Institute for Foreign Policy Analysis, *The Future of US Land-based Strategic Forces,* A Conference Report, (Cambridge: Institute for Foreign Policy Analysis, September 1979), pp. 23-24.

5. For the purposes of this monograph, fixed cost is calculated by multiplying the baseline quantity of shelters and missiles times their marginal costs and subtracting the total from the baseline total life cycle cost. If greater accuracy were desired the learning curve phenomenon would have to be considered in the calculation of fixed cost. At the margin, the error introduced by neglecting the learning curve phenomenon does not substantively alter the analyses or conclusions of this paper.

Chapter 4. Defending MPS-Based ICBMS—Enhancing Leverage

In the previous chapter it was shown that the United States could, theoretically, expand an MPS basing system by proliferating protective shelters to insure survival of a portion of the ICBM force *no* matter how large the threat. In practice the size of an MPS system would be bounded by funding, land, ecological, and political constraints. At some point, if the threat continued to grow, the United States might find it economical to augment the MPS basing system by deploying a complementary ballistic missile defense (BMD) system.

A BMD system designed to defend selectively only those shelters actually containing an ICBM could further complicate the already complex task of the attacker. For example, in the baseline MPS deployment described in Chapter 3, each of *200 ICBMs has* 23 associated shelters. To attack one US ICBM equipped with 10 warheads, the Soviets would have to expend 23 RVs, one for each shelter. If the United States deployed a single BMD interceptor capable of destroying the first RV correctly targeted on the ICBM, the Soviets would have to expend two RVs against each shelter (46 attacking RVs) to destroy a single 10-warhead ICBM. In this simplistic example, assuming perfect attacking RVs and defending interceptors and no requirement for BMD self-defense, the leverage of the

MPS deployment is doubled by the addition of a single BMD interceptor.

Is such a BMD system feasible? How could it work? Could it survive? Would the BMD system disclose the location of the defended ICBM? How much defense would it provide and how much would it cost? To answer these questions and to probe in greater detail the value of defending MPS-based ICBMs, consider as an illustrative baseline BMD system the Army proposed Low Altitude Defense System (LoADS).

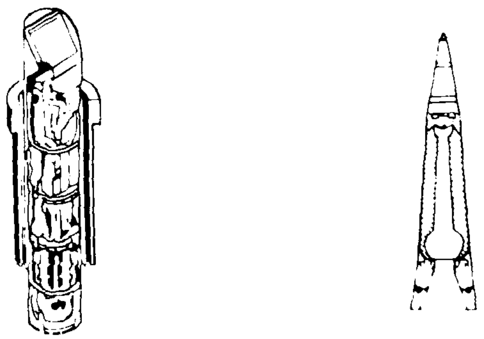
The concept for LoADS has evolved from the earlier *SAFEGUARD and Site Defense* BMD technologies, but with a substantial reduction in both required performance and physical size. Only the requirement for hardening against nuclear effects is greater than for the earlier systems.[1]

A LoADS fire unit, as presently conceived, contains a small, single faced, phased array radar; a data processor (DP); and one or more single stage interceptor missiles (see Figure 4-1). To focus the analysis, the LoADS fire unit is postulated to have two interceptors. Other configurations are also possible. The complete fire unit with interceptors can be mounted in an MX Transporter and moved along the road between protective shelters in the same fashion as the MX missile and mobile launcher. The fire unit is compatible with MX and can be housed in a vacant protective shelter where it remains essentially dormant, providing no signature which would disclose either its location or that of the defended MX. It can be moved among the protective structures and, when on the road, is indistinguishable from the MX.

The 10-year life cycle cost of a 200-fire unit LoADS deployment compatible with baseline MX is estimated by the Army to be $6.2 billion in constant FY 80 dollars, of which $1.5 billion is for research and development; $3.5 billion is for investment including required modifications to MX protective structures and procurement of radars, data processors, interceptors, C^3, and transporter vehicles; and $1.2 billion is for operating the system during deployment and for 10 years following achievement of full operating capability. At the margin the incremental 10-year life cycle cost to procure and operate additional fire units, above the 200-fire unit baseline, is $21.72 million per fire unit.

FIGURE 4-1

COMPONENTS OF Lo ADS FIRE UNIT[2]



•SMALL PHASED ARRAY (1/40 SITE DEFENSE)

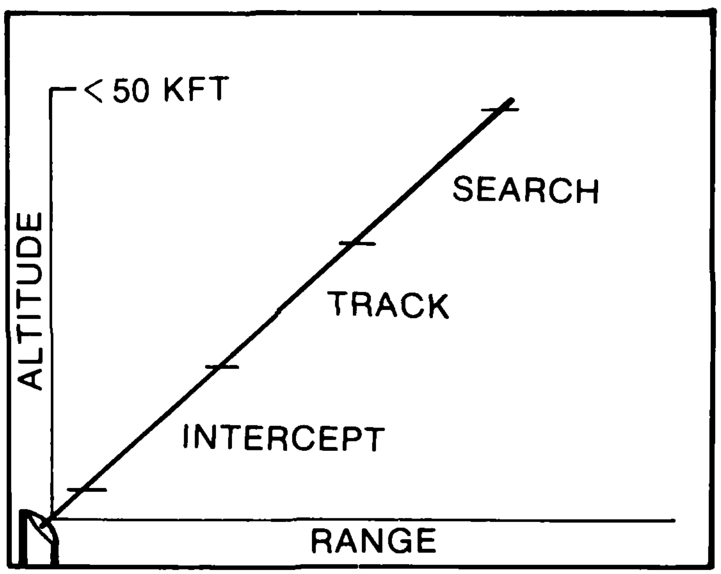
•SINGLE STAGE (1/2 SPRINT SIZE)

•DISTRIBUTED DP

A Soviet counter-force attack against the MPS-based MX would initially be detected by existing satellite and BMEWS warning systems. Minutes prior to the penetrating RVs arriving at the MPS field, the dormant fire unit would be deployed from the protective shelter and activated. The radar and data processor are designed to operate in the terminal regime of RV flight. In this regime the atmosphere assists in the tasks of discrimination and tracking by slowing the RV, producing a discernable wake behind the RV, and slowing down lighter weight objects such as chaff and decoys. The radar searches the threat cone that must be entered by the properly targeted RV (see Figure 4-2) to an altitude of 50,000 feet. High resolution track commences at about 40,000 feet and the data processor directs the interceptor missile to a designated intercept point between 5,000 and 20,000 feet altitude where the incoming RV is

FIGURE 4-2

THE LoADS FIRE UNIT OPERATING REGIME[2]



destroyed by the detonation of the interceptor's nuclear warhead. The entire operation from search through detonation takes place in a time regime under 10 seconds, limiting the opportunity for multiple sequential intercepts against a single RV.[2]

Note: Before proceeding with the details and analysis of defense, some readers will find this a convenient point to skip directly to Chapter 5 which provides a summary, graphical display, and analysis of the undefended and defended cases developed in Chapters 3 and 4.

Using the LoADS concept as an illustrative baseline for active defense, consider how the offense might attack a preferentially defended MPS field. First, the offense would have to choose between the leakage and exhaustion attack modes.[3] In a leakage attack, all shelters are attacked uniformly to the same level with kills dependent upon defense fallibility. In essence, RVs "leak" through an imperfect defense to destroy their targets. In an exhaustion attack, the offense commits all available RVs to saturate as large a portion of the defense as possible by expending one more RV than the defense has interceptors. In this attack the offense plans to destroy all ICBMs in that portion of the field attacked, regardless of the reliability of the defense and at the expense of not attacking other portions of the field.

To illustrate the difference between the two modes of attack, consider an MPS field of 100 protective shelters containing 10 ICBMs, each defended by a single interceptor. The attacker has 100 RVs available to attack this field. In a leakage attack, each protective shelter would be targeted by one RV on the assumption that some interceptors would be unreliable, permitting the destruction of the ICBMs they defend. In the exhaustion attack, half of the shelters would be targeted by two RVs each, saturating the defense and destroying 50 shelters. The remaining 50 shelters would not be attacked at all. In this example, the exhaustion attack is superior for the attacker when defense effectiveness is greater than 0.5. For defense effectiveness less than 0.5, the leakage attack would destroy more ICBMs.

Sheltering the LoADS fire unit in one of the ICBM protective structures introduces the additional requirement of LoADS self-defense. If the shelter containing the fire unit comes under attack before the MX shelter, LoADS would have to expend one of its interceptors to survive. As a practical rule, BMD firing doctrine would never permit the firing of the second interceptor for LoADS self-defense. If the LoADS shelter came under attack by two RVs before the MX shelter was threatened, one interceptor would be fired in self-defense. The second interceptor would be held back for MX defense, taking the chance that the second RV might be defective, rather than exhausting the fire unit and creating the certainty of leaving MX undefended.[4]

The selection by the offense of which attack strategy to use will be driven by the offense estimation of the quantity and reliability of

their RVs and the effectiveness of the defense against which the RVs will be targeted.

Chapters 2 and 3 discussed the first two factors in developing Threats A through E. The third factor, defense effectiveness, is the product of the probability of success of the following events:

- Early warning systems detect the threat and LoADS activation command is issued.

- Tactical communication and LoADS fire units are operationally effective, deploy from the protective shelter, and transition to the active mode of operation from the dormant state upon receipt of the activation command.

- LoADS radar searches, discriminates, acquires, and tracks threatening RVs.

- Fire unit data processor calculates the correct intercept point.

- Interceptor missile launches and flies to intercept point.

- Warhead detonates and the combination of yield and accuracy are sufficient to disable the attacking RV.

In addition to being dependent upon the ultimate reliability of as-yet-untested LoADS components, defense effectiveness can be altered by external factors. Threat tactics such as preemptive strikes against warning systems, nuclear pin-down[5] strikes, and penetration aids such as decoys, chaff, maneuvering RVs (MaRVs), small RVs, and jammers could contribute to reducing defense effectiveness.

Considering the uncertainties attendant in estimating defense effectiveness but recognizing the need for an estimate for analytical purposes, assume, for the following illustration, that two of every three interceptors deployed can effectively engage the threatening RV, i.e., single shot probability of kill (SSPK) equals .667. Now consider a leakage attack by Threat A against the baseline LoADS-defended MX-MPS deployment of 23 shelters per MX:

- Of 4,600 shelters, 4,044 are targeted and 556 escape attack, leaving: .... 24 ICBMs

- Of 4,044 RVs launched, 19% (1-DE) fail to destroy their target, leaving 768 additional shelters with . . . . 33 ICBMs

- In the 3,276 shelters actually engaged are 142 ICBMs, each defended by one interceptor with .667 probability of kill (other interceptors are consumed in self-defense or held in reserve), leaving: . . . . 95 ICBMs

- Of the original 200 ICBMs deployed, the total surviving the leakage attack is: . . . . 152 ICBMs

The leakage attack can be modeled by modifying equation (3-1) to consider defensive interceptors:

$$ICBM_S = ICBM_d \times \left[1 - \frac{RV \times DE}{PS} \times (1\text{-}SSPK)\right] \qquad (4\text{-}1)$$

provided $RV \leq PS$. Using equation (4-1) for the example above

$$ICBM_S = 200 \times \left[1 - \frac{4044 \times .81}{4600} \times (1 - .667)\right] = 152 \text{ ICBMs}$$

Next consider an exhaustion attack by the same threat.

- Of 4,600 shelters, 2,022 are targeted by 2 RVs each and 2,578 are not targeted at all, leaving: . . . . 112 ICBMs

- Of 2,022 shelters attacked, 3.6%, $(1\text{-DE})^2$, will be targeted by 2 RVs, both of which fail to destroy the shelter, leaving 73 shelters with: . . . . 3 ICBMs

- The 1,949 shelters actually engaged conceal 85 ICBMs and 85 fire units. The attacker "walks" the RVs sequentially through the MPS field in two waves. The first wave of 1,949 RVs exhausts all relevant interceptors through MX defense, LoADS self-defense, and destruction of LoADS fire units. The second wave destroys 81% of the remaining shelters, leaving 370 shelters with: . . . . 16 ICBMs

- Of the original 200 ICBMs deployed, the total surviving the exhaustion attack is . . . . 131 ICBMs

The exhaustion attack, with approximately 20 fewer surviving ICBMs than the leakage attack, is clearly superior for the attacker under the conditions of the example.

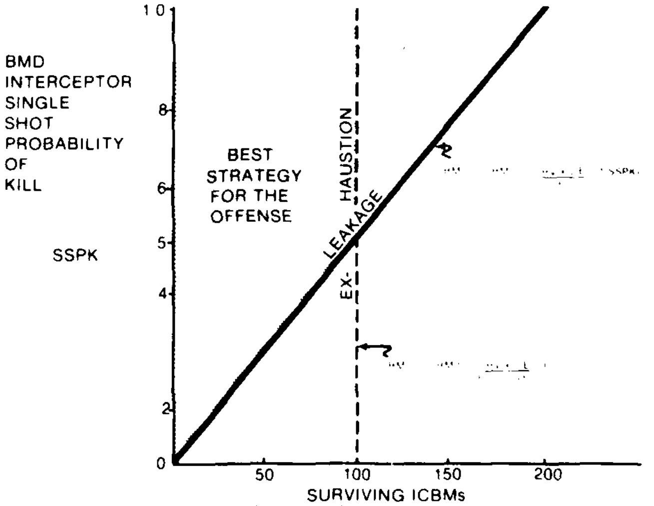
The exhaustion attack can be modeled, ignoring second-order terms, by the expression:

$$ICBM_s = ICBM_d \times \left[1 - \frac{RV \times DE}{(FU + 1) \times PS}\right] \qquad (4\text{-}2)$$

where; FU = fire unit interceptor missiles remaining after required self-defense[6] and $RV \leq (FU+1) \times PS$.

Using equations (4-1) and (4-2), the number of survivors are plotted on Figure 4-3 for various SSPKs for leakage and exhaustion attacks. For SSPK greater than 0.5, exhaustion is the most advantageous mode for the attacker. To focus the analysis, the exhaustion attack (most demanding case for the defense) is assumed for the remainder of this paper.

FIGURE 4-3
ICBM
SURVIVORS FOR VARYING INTERCEPTOR SSPK*
(Leakage and Exhaustion Attacks)



*EXAMPLE FOR CASE WHERE RV PS and DE 1

Using Equation (4-2) to find the number of surviving ICBMs for the example above:

$$ICBM_S = 200 \times \left[1 - \frac{4044 \times .81}{(1+1) \times 4600}\right]$$

$ICBM_S = 129$, as a first order approximation.

Recall that, in the undefended case of Chapter 3, only 58 ICBMs survived the same threat. In neither the defended nor undefended cases would a Threat A attack be advantageous to the attacker. In fact, for the defended case an attack would serve to disarm the attacker while leaving the defended ICBMs more than 60 percent intact.

The number of shelters required to provide a specified number of surviving ICBMs for a given threat using an exhaustion attack can be found by solving equation (4-2) for shelters:

$$PS = \frac{DE \times RV \times ICBM_d}{(FU+1) \times (ICBM_d - ICBM_s)} \tag{4-3}$$

Using equation (4-3) the number of shelters required for half the LoADS-defended MPS-based ICBMs to survive a Threat B attack is calculated below:

$$PS = \frac{.73 \times 6492 \times 200}{(1+1) \times (200-100)}$$

$$PS = 4,739$$

This, as might be anticipated, is half the number of shelters required to obtain the same number of surviving ICBMs in the undefended case.

In the exhaustion attack, defense fallibility does not significantly influence the outcome. The attacker, in committing himself to an exhaustion attack, dedicates the number of RVs necessary to exhaust the defense plus one to destroy the target. Implicit is the assumption by the offense that the defense has a high probability of success (greater than 0.5) with each intercept. The defense can be best defeated, the exhaustion attack philosophy posits, by using all attacking assets to saturate as much of the defense as possible even at the expense of not attacking some of the targets at all.

Table 4-1 provides the number of protective shelters required to insure specified levels of surviving ICBMs when a LoADS-defended MPS field is attacked by Threats A through E and the quantity of deployed ICBMs is held constant at 200. This is CASE 3. *Defended Baseline MX*. The number of shelters required is half the number required for the undefended CASE 1 displayed in Table 3-2.

TABLE 4-1. CASE 3. SHELTERS REQUIRED (200 LoADS-Defended MX ICBMs Deployed)

	Threat				
Surviving ICBMs	A	B	C	D	E
	REQUIRED SHELTERS				
5	1,680	2,431	4,226	5,197	8,403
25	1,872	2,708	4,987	5,791	9,363
50	2,184	3,160	5,818	6,756	10,924
75	2,621	3,792	6,982	8,107	13,109
100	3,276	4,739	8,728	10,133	16,386

The cost of the CASE 3 LoADS-defended MPS deployment given in Table 4-1 can be calculated by adding the marginal cost of LoADS to the cost equation, equation (3-3), for undefended MPS basing:

$$COST_2 = COST_{f1} + COST_{f2} + ICBM_d \times (C_m + FU \times C_{fu}) + PS \times C_{ps} \quad (4\text{-}4)$$

Where: $COST_2$ = 10-year life cycle cost of LoADS-defended, MPS-based MX in FY 80 constant dollars

$COST_{f1}$ = Fixed Cost of MPS-based MX deployment defined in equation (3-3) ($18,474 M)

$COST_{f2}$ = Fixed cost for LoADS deployment ($1,790 M)[7]

FU = Number of LoADS fire units per deployed ICBM

C_{fu} = Variable cost to procure and operate incremental fire units ($21.72 M)

Equation (4-4) is a linear approximation which neglects the learning phenomenon. The equation will be most accurate for deployments near the baseline. The cost to provide a specified number of surviving ICBMs for the CASE 3 LoADS-defended MPS deployment is provided in Table 4-2 for Threats A through E. These costs are lower than for the undefended cases of Chapter 3.

TABLE 4-2. CASE 3. TEN-YEAR LIFE CYCLE COST (200 LoADS-Defended MX ICBMs Deployed)

Surviving ICBMs	Threat A	Threat B	Threat C	Threat D	Threat E
	FY 80 Dollars in Billions				
5	36.6	39.1	45.1	48.3	59.0
25	37.3	40.0	47.6	50.3	62.2
50	38 3	41.6	50.4	53.5	67.3
75	39.8	43.6	54.2	58.0	74.6
100	41.9	46.8	60.0	64.7	85.5

If the United States did not constrain itself to 200 MX missiles deployed, but permitted the number of protective shelters and deployed MX missiles with LoADS fire units to vary with the threat, the mix of shelters and missiles could be optimized, as was done in Chapter 3, to produce the required number of surviving ICBMs at minimum cost.

Solving equation (4-2) for $ICBM_d$, substituting this value into equation (4-4) and differentiating with respect to PS, yields the expression for optimizing protective shelters:

$$PS = \frac{DE \times RV}{(FU + 1)} + \sqrt{\frac{DE \times RV \times (C_m + FU \times C_{fu}) \times ICBM_s}{(FU + 1) \times C_{ps}}} \quad (4\text{-}5)$$

Substituting equation (4-3) for PS into equation (4-4) and differentiating with respect to $ICBM_d$ yields the equation for optimizing deployed ICBMs:

$$ICBM_d = ICBM_s + \sqrt{\frac{DE \times RV \times C_{ps} \times ICBM_s}{(FU + 1) \times (C_m + FU \times C_{fu})}} \qquad (4\text{-}6)$$

Substituting equations (4-5) and (4-6) back into (4-4) yields the equation for optimizing the mix of shelters and defended ICBMs to maximize surviving ICBMs for various threats at minimum cost:

$$COST_t = COST_{f1} + COST_{f2} + \left[\sqrt{(C_m + FU \times C_{fu}) \times ICBM_s} + \sqrt{\frac{C_{ps} \times DE \times RV}{(FU + 1)}}\right]^2 \qquad (4\text{-}7)$$

Equations (4-5) through (4-7) are used to calculate the minimum cost mix of protective shelters and defended ICBMs required to absorb growing threats while preserving specified levels of surviving ICBMs. This deployment case is the fourth and last to be analyzed, *Defended Optimized MX/MPS/BMD Mix.* The CASE 4 quantity of protective structures and ICBMs is displayed in Table 4-3 and the associated costs are provided in Table 4-4.

The data for defended Cases 3 and 4 are analyzed and compared graphically with data for undefended Cases 1 and 2 in Chapter 5.

TABLE 4-3. CASE 4. SHELTERS AND DEFENDED ICBMs REQUIRED (Optimal Mix)

Threat

	A		*B*		*C*		*D*		*E*	
Surviving ICBMs	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$	PS	$ICBM_d$
5	2003	27	2809	32	4959	42	5708	44	9009	55
25	2454	75	3351	85	5696	107	6502	113	10018	137
50	2792	121	3758	135	6247	166	7096	175	10774	209
75	3051	162	4070	180	6671	217	7552	228	11354	269
100	3270	200	4333	221	7028	264	7937	276	11843	324

Note: PS = Protective Shelter and $ICBM_d$ = deployed ICBMs

TABLE 4-4. CASE 4.
TEN-YEAR LIFE CYCLE COST
(Optimal Mix-with Defense)

Surviving ICBMs	Threat A	B	C	D	E
	FY 80 Dollars in Billions				
5	28.4	31.3	39.0	41.6	53.2
25	32.5	36.0	44.9	48.0	60.9
50	36.1	40.0	50.0	53.3	67.3
75	39.1	43.5	54.1	57.6	72.5
100	41.9	46.6	57.8	61.5	77.1

Chapter 4. ENDNOTES

1. William A. Davis, Jr., "Ballistic Missile Defense Into the Eighties," *National Defense*, September-October 1979, pp. 55-63.

2. Ibid., p. 60.

3. Background information used to develop the discussion on exhaustion and leakage attacks provided by: Capt. Gregg A. Smith, "Ballistic Missile defense and the MX program," 15 May 1979, HQ USAF/SASI, Washington, DC.

4. If all RVs were launched so as to arrive simultaneously over the MPS field (similar to an artillery time-on-target), both LoADS interceptors could be used to defend the ICBM, as LoADS self-defense would not be required. To force the defense to expend some interceptors for self-defense of the LoADS fireunit, the attacker could strike protective shelters sequentially rather than simultaneously. In a sequential attack, fratricide (destruction of RVs resultant from detonation of other attacking RVs) could be minimized by "walking" the RVs through the MPS field, such as an East-West or South-North walk. A proper walk avoids RVs passing through the nuclear effects of earlier RVs. Given random placement of the LoADS fire units with regard to the ICMBs they defend, half the fire units would come under attack before the MX and would expend one interceptor in self-defense, leaving one interceptor available for MX defense. At no time would a fire unit expend its last interceptor in self-defense as it would be wiser to accept the small probability of surviving a hit and then defending the MX.

5. In pin-down ". . . multiple high-altitude nuclear explosions produce repeated bursts of x-rays, which can reliably damage not only the electronics of the ICBMs during boost phase but also the structure." From: Richard L. Garwin, "Launch Under Attack to Redress MINUTEMAN Vulnerability," *International Security*, Winter 1979-80, p. 133. Also see: R. L. Garwin and H. A. Bethe, "Anti-Ballistic-Missile Systems," *Scientific American*, Vol. 218, No. 3 (March 1968), pp. 21-31.

6. LoADS self-defense would not require the expenditure of additional interceptor missiles if the LoADS fire unit was collocated with the defended ICBM. However, joint occupation of a single shelter would entail enlarging all shelters to handle BMD, eroding much of the economy inherent in preferential defense. Placing two interceptor missiles on the LoADS fire unit, one of which is available to perform self-defense, permits the doubling of MPS leverage without collocation of BMD and ICBM systems. Tripling of leverage is possible, but would require the addition of two more interceptor missiles to the LoADS fire unit. Shelter dimensions are the limiting factor. The use of additional shelters beyond one for BMD is not productive because the use of additional shelters exacerbates the self-defense problem.

7. Fixed cost is an approximation calculated by multiplying the baseline quantity of 200 fire units times their marginal cost and subtracting the total from total life cycle cost. The remainder is called fixed cost for the purpose of this monograph. If greater accuracy is required, the effect of the learning curve phenomenon would have to be considered. At the margin the error introduced by this convention is not significant.

Chapter 5.
Analysis of Alternatives—Evaluating the New Math

The five threats developed in Chapter 2, ranging from under 6,-000 RVs to almost 23,000 RVs, have been used to test the defended and undefended deployment cases postulated in Chapters 3 and 4. The deployment cases are summarized below to facilitate comparison of alternatives:

CASE 1. *Undefended baseline MX.* Two hundred deployed ICBMs. Protective shelters vary in quantity to absorb growing threats while preserving a specified level of surviving ICBMs.

CASE 2. *Undefended optimized MX/MPS mix.* Both protective shelters and quantity of ICBMs vary with growing threats in a mix optimized to preserve a specified level of surviving ICBMs at minimum cost.

CASE 3. *Defended baseline MX.* Two hundred deployed ICBMs. One LoADS fire unit with two interceptor missiles preferentially defends each ICBM. Protective shelters vary in quantity to absorb growing threats while preserving a specified level of surviving ICBMs.

CASE 4. *Defended optimized MX/MPS/BMD mix.* Protective shelters and defended ICBMs vary optimally in quantity and mix to absorb growing threats while preserving a specified level of surviving ICBMs at minimum cost.

To better focus the analysis, in this chapter the desired level of survivors will be held constant at 100 ICBMs armed with 1,000 warheads. This level of surviving warheads would preserve the US option of destroying most Soviet industrial or military targets with ICBMs after absorbing a Soviet first-strike attack.[1] Figure 5-1 depicts the cost required for each deployment option to preserve 100 surviving ICBMs as a function of Soviet ICBM warheads. The Soviet ICBM MIRVs shown on the figures of this chapter include 1,708 RVs which would be absorbed by Minuteman and Titan silos rather than MX shelters.

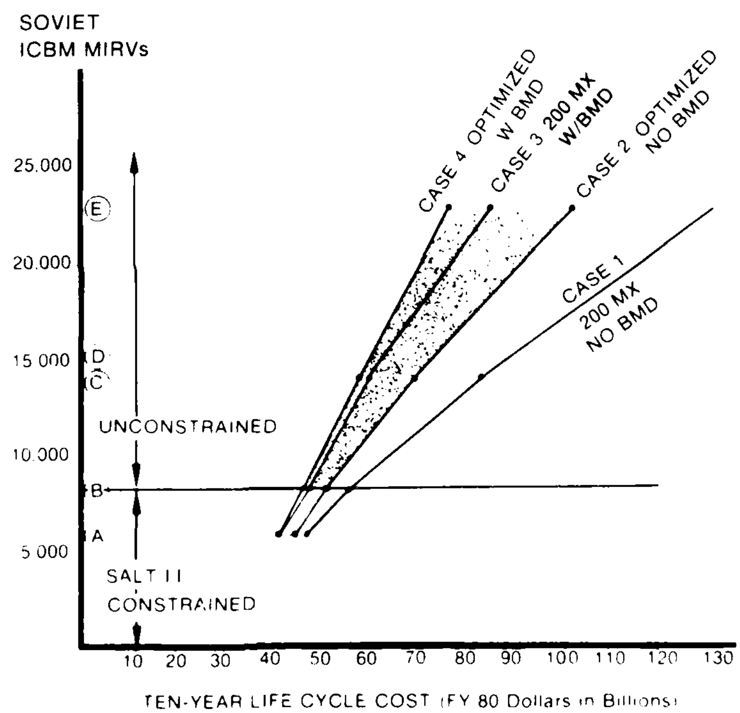
For unconstrained threats, the shaded region of Figures 5-1, 5-2, and 5-3 is intended to focus the analysis on the two cost optimized cases: undefended Case 2 and defended Case 4. For a mid-range threat of 15,000 RVs, Case 4 with defense would cost approximately $12 billion less than the undefended Case 2 to produce the same level of surviving ICBMs. Additionally, the defended case would require 150 fewer ICBMs, 5,800 fewer shelters, and 14,500 fewer fenced acres than the undefended case. Water and power would also be conserved. For the high threat, the savings would be approximately $25 billion dollars, 190 ICBMs, 8,500 shelters, and 21,300 fenced acres with proportional water and energy conservation.

It is reportedly more expensive for the Soviets to build warheads (estimated to cost $8 million each) than for the United States to construct additional shelters.[2] If warheads beyond the levels of Threat A cost the Soviets $8 million apiece, it would cost the Soviets approximately $74 billion to reach 15,000 RVs. If the United States chooses to respond to this increase by adding protective structures alone (Case 1), the life cycle cost above baseline MX would be $50 billion. Optimizing the mix of undefended ICBMs and protective structures (Case 2) would cost $34 billion above the baseline. Optimizing the mix and providing preferential defense (Case 4) would cost $20 billion above baseline MX.[3]

This, of course, is a simplistic, one-dimensional treatment of a multi-dimensional issue. Cost-effectiveness may not be a considera-

FIGURE 5-1

TEN-YEAR LIFE CYCLE COST REQUIRED TO PROVIDE 100 SURVIVING ICBMs



tion in a Soviet decision to proliferate warheads or their analysis might be different. The point is that the notion that small increases in offensive funding can induce large increases in defensive funding is not self-evident for the representative cases analyzed in this paper.

Factors, in addition to cost, are explored; final conclusions drawn; and recommendations provided in the next chapter.

FIGURE 5-2

DEPLOYED ICBMs REQUIRED TO PROVIDE 100 SURVIVING ICBMs

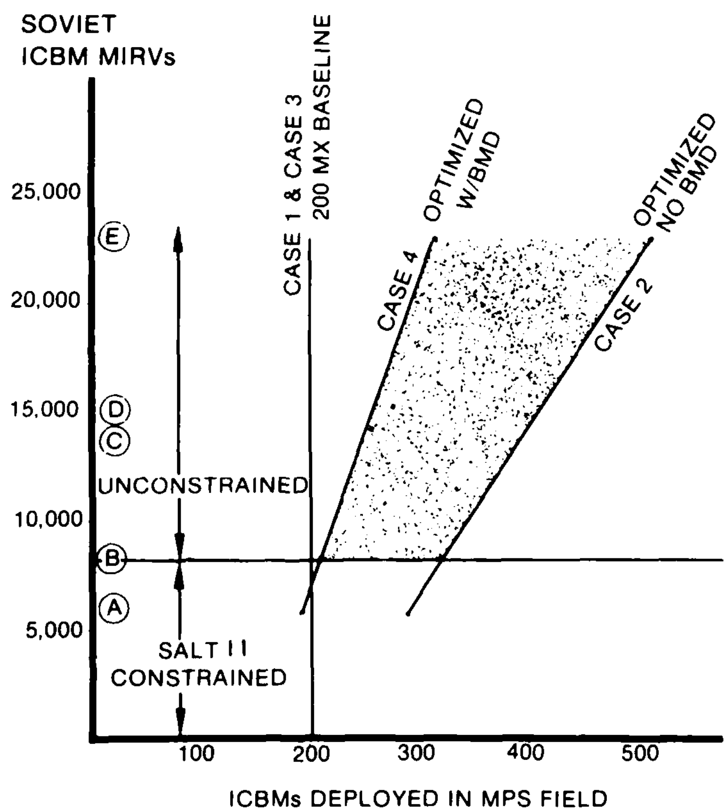
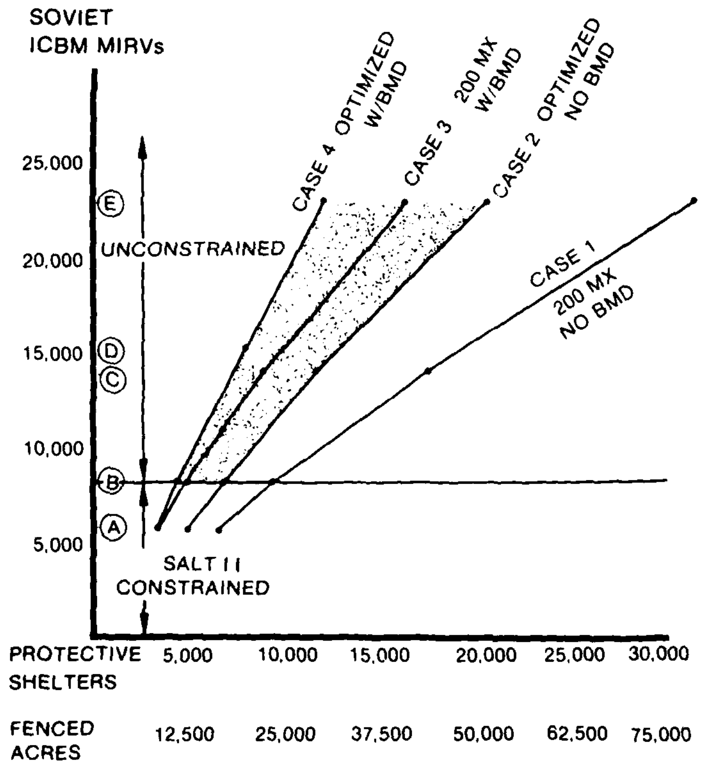


FIGURE 5-3

PROTECTIVE SHELTERS AND FENCED LAND REQUIRED TO PROVIDE 100 SURVIVING ICBMs



Chapter 5. ENDNOTES

1. See: Desmand Ball, "The MX Basing Decision," *Survival,* Volume XXII, Number 2, (March/April 1980), p. 61; and Congressional Budget Office, *The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications,* Budget Issue Paper for Fiscal Year 1980, June 1979, pp. XVIII and 22-23.

2. See: George C. Wilson, "MX Blockbuster Losing Support In Utah, on Hill," *The Washingtcn Post,* 13 March 1980, p. A1; and Congressional Budget Office, *The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications,* Budget Issue Paper for Fiscal Year 1980, June 1979, pp. 53-54.

3. The sensitivity of these trends, which demonstrates the cost effectiveness of defense over the proliferation of undefended protective structures, is tested in Appendix A.

Chapter 6. Defending MPS-Based ICBMs— The Bottom Line

Coping with Threats Beyond SALT II

The advantages and disadvantages of BMD relative to proliferation of protective structures are enumerated in Table 6-1. For threats exceeding SALT II constraints, BMD, as a means of defending deceptively based ICBMs, offers advantages in responsiveness and reduced resource consumption over the proliferation of protective structures and undefended ICBMs. The major disadvantage of BMD, other than the ABM Treaty issue, is that it and the warning systems upon which it depends are subject to countermeasures; whereas, protective structures are essentially immune to defense suppression techniques other than ICBM location disclosure.

Holding consideration of the ABM Treaty issue temporarily in abeyance, the remaining issues may be resolved as follows:

- If funds and suitable geography are available, congressional approval is forthcoming, and the increased threat evolves gradually rather than as a *fait accompli*, then protective structure proliferation would provide a more reliable counter to growing threats than BMD.

- If on the other hand, any single issue—such as land availability or congressional approval—would preclude proliferation of shelters, then BMD, even with its attendant risks, could be a feasible and resource-effective way to counter a growing threat to MPS-based ICBMs.

TABLE 6-1. COPING WITH THREATS BEYOND SALT II (BMD or more protective structures)

ADVANTAGES OF BMD RELATIVE TO PROTECTIVE STRUCTURES

- After prototype demonstration, BMD permits more timely response to Soviet SALT breakout (200 fire units can be deployed faster than 4,600 shelters can be constructed).

- BMD is less resource intensive; it consumes fewer dollars and less land, water, and energy than additional protective structures.

- BMD is less demanding politically and environmentally and would expose a smaller area of the United States to a Soviet counterforce attack.

DISADVANTAGES OF BMD RELATIVE TO PROTECTIVE STRUCTURES

- BMD is dependent on early warning and radar detection which are subject to defense suppression measures such as maneuvering RVs (MARVs), pin-down, and penetration aids such as smaller RVs, jamming, chaff, and decoys.

- BMD requires potential for technological growth (and associated cost growth) to counter improved offensive weapons such as improved SLBMs.

- BMD requires revision or abrogation of the ABM Treaty.

The ABM Treaty

Turning now to the ABM Treaty, several questions may be raised. If the United States elects to develop a mobile BMD system for MX, what are the implications for the ABM Treaty? Does the treaty permit

development or deployment of a system similar in concept to LoADS? Can the treaty be modified if necessary? Would modification or abrogation be in the interest of the United States and what would be the probable response of the Soviets? To answer these questions it is first necessary to understand the basic components of the 1972 ABM Treaty and 1974 Protocol. These are reproduced in their entirety in Appendix B.

In summary, the ABM Treaty, as amended by the protocol, restricts the United States and the Soviets from developing or deploying nationwide ABM defenses. Each side is permitted to have one system within specified quantitative and qualitative limits. The United States elected to place its system, restricted to not more than 100 interceptors, 2 large ABM radars, and 18 smaller ABM radars, in the Minuteman fields near Grand Forks, N.D. The Soviets selected Moscow as their preferred site. Both sides agreed not to develop, test, or deploy ABM launchers capable of multiple launch or rapid reload of interceptors. Interceptors with more than one independently guided warhead are also barred. Missiles designed for defense against aircraft cannot be upgraded for use against ICBMs or SLBMs. BMD warning radars may be deployed, but only on the periphery of national territory and oriented outward. Development, testing, or deployment of sea-based, air-based, space-based, or mobile land-based ABM systems is prohibited.

The treaty is of unlimited duration although either party may withdraw from the treaty 6 months after giving notice. The treaty prescribes reviews of its provisions every 5 years. The first review, which began in October 1977, resulted in no changes to the treaty. The next review is scheduled for October 1982.

Several elements of the LoADS concept, if pursued to system development and deployment, would require abrogation or renegotiation of the treaty. The specific articles affected and the issues raised are:

- Article III: limits the US ABM system defending ICBMs to an area of 150 km radius (at Grand Forks, ND). The system is limited to 100 launchers and interceptor missiles, two large ABM radars, and 18 smaller ABM radars.

- Article V: precludes development, testing, or deployment of mobile land-based ABM systems or components. ABM launchers capable of launching more than one interceptor at a time are also excluded.

- Article XII: prohibits the use of concealment measures which impede verification by national technical means.

A BMD system protecting MPS-based ICBMs must be survivable and should be economical. Survivability requires deceptive basing, mobility, and active self-defense. Economy requires sufficient numbers of interceptors and radars to provide required ICBM survivability without resorting to the less resource-efficient proliferation of protective shelters. These requirements cannot be met within the limitations of the current treaty.

ABM Treaty options available to the United States should be considered in the context of the threat and SALT environment. Three threat/SALT scenarios which test the full range of US ABM Treaty options can be constructed using the threats developed in Chapter 2. The scenarios are:

- *SALT Compliance*—Both parties abide by SALT II constraints and earnest negotiations for extending time limits and expanding the discussions continue into the post-1990 period (Threats A or B).

- *Graceful SALT Failure*—SALT II does not enter into force. Soviets openly ignore limits and gradually deploy MIRVed ICBMs or fractionate warheads beyond SALT constraints while continuing negotiations for a new strategic arms agreement (Threats C or D).

- *Catastrophic SALT Breakout*—Soviets maintain public posture of SALT compliance but are detected, after the fact, to have successfully increased warheads substantially beyond SALT limits (Threat E).

If the Soviets exhibit a continued willingness to remain within the limits of SALT II through 1985 and into the post-1990 period (com-

pliance scenario), the United States should abide by the ABM Treaty, relying on MPS basing for ICBM survivability. Development of generic BMD systems to protect ICBMs should continue, within treaty limits, with emphasis on a rapidly deployable BMD to counter a potential SALT breakout. Limited modifications to the ABM Treaty should be considered during the 1982 and 1987 reviews which would permit development, but not deployment, of a mobile BMD system.

If SALT II does not enter into force and the threat to US ICBMs gradually grows beyond SALT limits (graceful SALT failure scenario), the United States will be forced, temporarily, to rely on the deterrent value of the air and sea legs of the Triad and a policy of launch-on-warning for ICBM survivability. Proliferation of protective structures, more ICBMs, BMD, or some combination of these will compete as longer term solutions which would ultimately provide the President greater flexibility in the event of attack.

In this scenario the ABM Treaty should not be immediately abrogated provided the Soviets continue in compliance; however, more ambitious modifications should be proposed for the 1982 and 1987 reviews:

- Revise Article III to permit deployment of BMD in conjunction with deceptively based, mobile ICBMs in Nevada and Utah (radius greater than 150 km). Permit BMD force levels of 200 small radars and launchers, and 400 interceptor missiles.

- Modify Article V to permit development, testing, and deployment of a mobile BMD system. Clarify language with regard to multiple launch so that a LoADS type fire unit is not considered a multiple launcher but rather is considered to bear multiple launchers each capable of a single launch.

- Clarify Article XII so that MPS-type deceptive basing of BMD in MX protective structures does not constitute deliberate concealment measures which impede verification by national technical means.

If the Soviets expand the threat or abrogate the ABM Treaty, or a serious covert SALT infraction is uncovered (catastrophic SALT breakout scenario), the ABM Treaty is no longer a consideration in determining which offensive and defensive responses are required.

The other considerations of Table 6-1 should be used to develop the proper responses.

Conclusions and Recommendations

Given the advantages and disadvantages of defending deceptively based ICBMs, the delay in getting SALT II ratified, and the potential for SALT failure, what is the best course of action for the United States today? Five alternatives [illegible]

(1) *Continue to participate in the SALT process.* Deterrence is possible independent of the success of SALT; however, in the absence of verifiable limits, paying the high price of deterrence could test national will. The United States should encourage continuation of negotiations even if SALT II does not enter into force. The communication between superpowers inherent in the SALT process facilitates verification of strategic weapons capabilities and provides clues concerning long-term intentions. A *verifiable balanced* limit on total warheads is in the national security and economic interests of both the Soviets and the United States.

(2) *Deploy deceptively based, defendable, ICBMs.* MPS basing offers a cost effective means of maintaining ICBM survivability as long as the threat remains within SALT limits. The ICBM deployment scheme, shelter spacing, and shelter size should be designed to facilitate the rapid deployment of BMD as a precaution against SALT failure.

(3) *Modify ABM Treaty.* Negotiate changes to the ABM Treaty during the 1982 review which would permit accelerated development and testing but not deployment of mobile BMD.

(4) *Accelerate development of rapidly deployable, mobile, compatible BMD.* Accelerate research and development of a BMD system which is both rapidly deployable and compatible with deceptively based ICBMs but do not deploy mobile BMD or otherwise violate the modified ABM Treaty unless the Soviets either violate the ABM Treaty or the SALT limits. Increase the five-year defense program by .2 percent per year ($300 million) to fund this effort. The US goal should be to have a fully developed and tested prototype BMD system, capable of rapid production and deployment once the deceptively based ICBM

system it defends has achieved initial operating capability (end of 1985 for MX). Provision for technological growth should be incorporated into BMD system design to minimize the risk that the system could be defeated by improved offensive weapons and tactics.

(5) *Respond to SALT failure with mix of shelters, ICBMs, and BMD.* If SALT fails to constrain the threat, respond with the most effective mix of shelters, ICBMs, and BMD. Proper mix will depend on status of BMD development and ICBM deployment at the time SALT failure is detected. The cost to deploy BMD for baseline MX (once BMD prototyping is completed) is about $.7 billion a year for five years, an increase of about .4 percent above the projected FY 85 defense budget.

We are at a critical stage in nuclear weaponry with many of the revolutionary advances in offensive technology already exploited. Defensive technology is maturing and the next two decades could see the ascendency of defense as a principal contributor to deterrence if: 1) deliverable nuclear weapons continue to proliferate; 2) the ability of defensive technology to counter offensive improvements is established; and 3) the deterrent and, should deterrence fail, war winning attributes inherent in defensive weapons can be exploited.

The quantitative analyses of this monograph ~~have~~ served to illustrate and validate the fundamental concept that preferential defense can economically contribute to the survivability of deceptively based weapons systems. This concept can be applied to ICBMs, with the result that the leverage advantage shifts in favor of the strategic defense. Specifically, the Soviets, in a first strike, can be made to expend more RVs than they destroy. Thus, the incentive for a first strike is diminished and deterrence is enhanced. Defended ICBMs can survive, should deterrence fail, in numbers large enough to preclude military and subsequent political intimidation from an adventurous Soviet regime. These potent defensive concepts demand full consideration by our strategic planners as they seek to insure United States national security and preserve the strategic balance.

APPENDIX A
SENSITIVITY ANALYSIS

The LoADS concept is based on a maturing technology. While RV intercept has been demonstrated by earlier BMD systems, LoADS prototypes have yet to be built or tested and additional refinements are still under active consideration. These factors contribute to cost uncertainty. To test the sensitivity of the analyses of Chapter 5 to growth in LoADS cost, the equations for the defense were re-run with a 100 percent increase in LoADS fire unit cost. The results, depicted as dashed lines, are superimposed in Figures A-1 through A-3 over the figures used in Chapter 5. It can be seen from the figures that, although the cost of BMD is doubled, defense is still more cost effective than proliferation of protective structures for threats exceeding SALT II constraints. Thus, the conclusions of the monograph are insensitive to BMD cost growth within the range of 100 per cent.

FIGURE A-1

CASE 4. FIRE UNIT COST EXCURSION IMPACT ON DEPLOYMENT COST

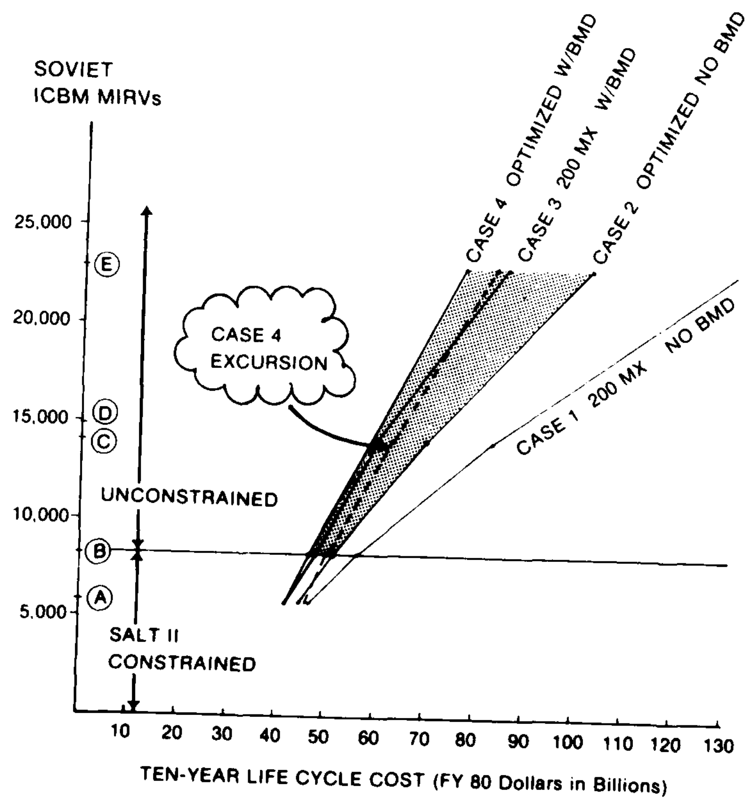


FIGURE A-2

CASE 4. FIRE UNIT COST EXCURSION IMPACT ON ICBMs REQUIRED

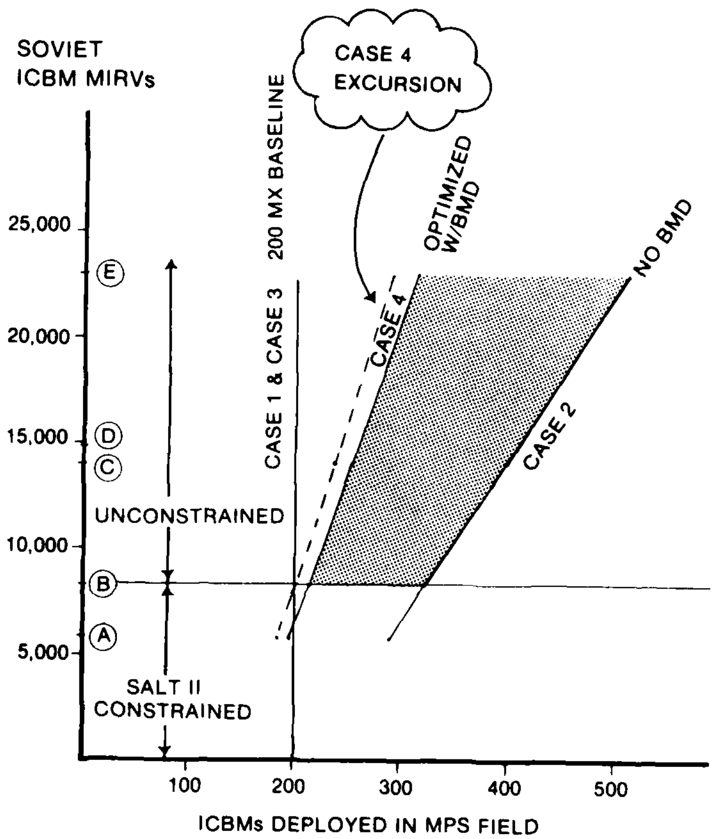
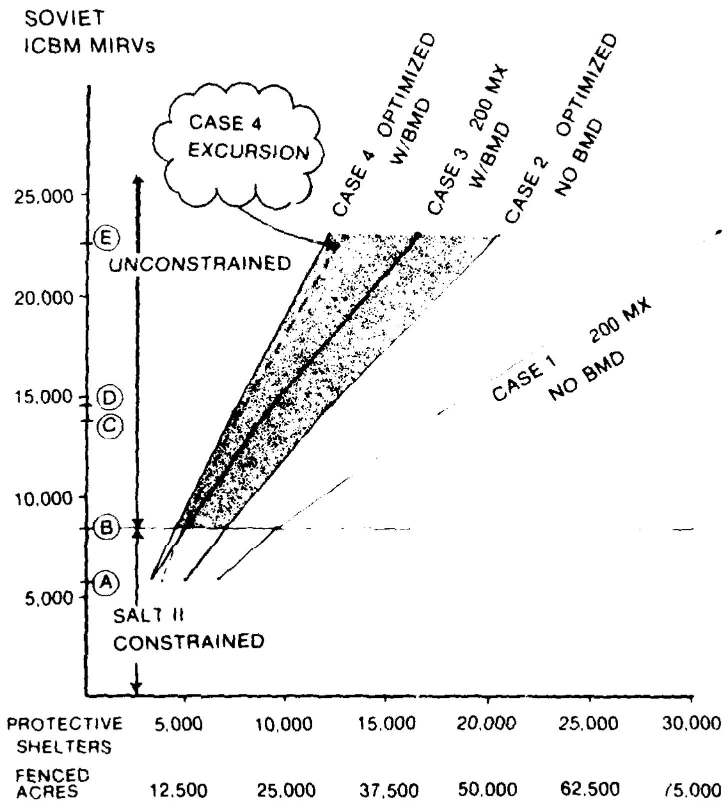


FIGURE A-3

CASE 4. FIRE UNIT COST EXCURSION IMPACT ON PROTECTIVE SHELTERS



APPENDIX B

THE 1972 ABM TREATY AND THE 1974 ABM PROTOCOL*

Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems

Signed at Moscow May 26, 1972

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from the premise that nuclear war would have devastating consequences for all mankind.

Considering that effective measures to limit anti-ballistic missile systems would be a substantial factor in curbing the race in strategic offensive arms and would lead to a decrease in the risk of outbreak of war involving nuclear weapons,

Proceeding from the premise that the limitation of anti-ballistic missile systems, as well as certain agreed measures with respect to the limitation of strategic offensive arms, would contribute to the creation of more favorable conditions for further negotiations on limiting strategic arms,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarmament, and general and complete disarmament,

Desiring to contribute to the relaxation of international tension and the strengthening of trust between States,

Have agreed as follows:

* Source: US Arms Control and Disarmament Agency, *Arms Control and Disarmament Agreements*, June 1977, pp. 130-150.

Article I

1. Each party undertakes to limit anti-ballistic missile (ABM) systems and to adopt other measures in accordance with the provisions of this Treaty.

2. Each Party undertakes not to deploy ABM systems for a defense of the territory of its country and not to provide a base for such a defense, and not to deploy ABM systems for defense of an individual region except as provided for in Article III of this Treaty.

Article II

1. For the purpose of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, *currently consisting of:*

(a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;
(b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and
(c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.

2. The ABM system components listed in paragraph 1 of this Article include those which are:

(a) operational;
(b) under construction;
(c) undergoing testing;
(d) undergoing overhaul, repair or conversion; or
(e) mothballed.

Article III

Each Party undertakes not to deploy ABM systems or their components except that:

(a) within one ABM system deployment area having a radius of one hundred and fifty kilometers and centered on the Party's national capital, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, and (2) ABM radars within no more than six ABM radar complexes, the area of each complex being circular and having a diameter of no more than three kilometers; and
(b) within one ABM system deployment area having a radius

of one hundred and fifty kilometers and containing ICBM silo launchers, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, (2) two large phased-array ABM radars comparable in potential to corresponding ABM radars operational or under construction on the date of signature of the Treaty in an ABM system deployment area containing ICBM silo launchers, and (3) no more than eighteen ABM radars each having a potential less than the potential of the smaller of the above-mentioned two large phased-array ABM radars.

Article IV

The limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges. Each Party may have no more than a total of fifteen ABM launchers at test ranges.

Article V

1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.

2. Each Party undertakes not to develop, test, or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, nor to modify deployed launchers to provide them with such a capability, nor to develop, test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers.

Article VI

To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by this Treaty, each Party undertakes:

(a) not to give missiles, launchers, or radars, other than ABM interceptor missiles, ABM launchers, or ABM radars, capabilities to counter strategic ballistic missiles or their elements in flight trajectory, and not to test them in an ABM mode; and

(b) not to deploy in the future radars for early warning of

strategic ballistic missile attack except at locations along the periphery of its national territory and oriented outward.

Article VII

Subject to the provisions of this Treaty, modernization and replacement of ABM systems or their components may be carried out.

Article VIII

ABM systems or their components in excess of the numbers or outside the areas specified in this Treaty, as well as ABM systems or their components prohibited by this Treaty, shall be destroyed or dismantled under agreed procedures within the shortest possible agreed period of time.

Article IX

To assure the viability and effectiveness of this Treaty, each Party undertakes not to transfer to other States, and not to deploy outside its national territory, ABM systems or their components limited by this Treaty.

Article X

Each Party undertakes not to assume any international obligations which would conflict with this Treaty.

Article XI

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.

Article XII

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national

technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.

3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

Article XIII

1. To promote the objectives and implementation of the provisions of this treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:

(a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;

(b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;

(c) consider questions involving unintended interference with national technical means of verification;

(d) consider possible changes in the strategic situation which have a bearing on the provisions of this treaty;

(e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this Treaty;

(f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty, including proposals for amendments in accordance with the provisions of this Treaty;

(g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.

2. The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Standing Consultative

Commission governing procedures, composition and other relevant matters.

Article XIV

1. Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing the entry into force of this Treaty.

2. Five years after entry into force of this treaty, and at five-year intervals thereafter, the Parties shall together conduct a review of this treaty.

Article XV

1. This Treaty shall be of unlimited duration.

2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

Article XVI

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. The Treaty shall enter into force on the day of the exchange of instruments of ratification.

2. This treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

Done at Moscow on May 26, 1972, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA
1

President of the United States of America

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS
2

General Secretary of the Central Committee of the CPSU

1. Richard Nixon
2. L. I. Brezhnev

Protocol to the Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-ballistic Missile Systems

Signed at Moscow July 3, 1974
Entered into force May 24, 1976

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from the Basic Principles of Relations between the United States of America and the Union of Soviet Socialist Republics signed on May 29, 1972,

Desiring to further the objectives of the Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems signed on May 26, 1972, hereinafter referred to as the Treaty,

Reaffirming their conviction that the adoption of further measures for the limitation of strategic arms would contribute to strengthening international peace and security,

Proceeding from the premise that further limitation of anti-ballistic missile systems will create more favorable conditions for the completion of work on a permanent agreement on more complete measures for the limitation of strategic offensive arms,

Have agreed as follows:

Article I

1. Each Party shall be limited at any one time to a single area out of the two provided in Article III of the Treaty for deployment of anti-ballistic missile (ABM) systems or their components and accordingly shall not exercise its right to deploy an ABM system or its components in the second of the two ABM system deployment areas permitted by Article III of the Treaty, except as an exchange of one permitted area for the other in accordance with Article II of this Protocol.

2. Accordingly, except as permitted by Article II of this Protocol: the United States of America shall not deploy an ABM system or its components in the area centered on its capital, as permitted by Article III (a) of the Treaty, and the Soviet Union shall not

deploy an ABM system or its components in the deployment area of intercontinental ballistic missile (ICBM) silo launchers permitted by Article III (b) of the Treaty.

Article II

1. Each Party shall have the right to dismantle or destroy its ABM system and the components thereof in the area where they are presently deployed and to deploy an ABM system or its components in the alternative area permitted by Article III of the Treaty, provided that prior to initiation of construction, notification is given in accord with the procedure agreed to by the Standing Consultative Commission, during the year beginning October 3, 1977, and ending October 2, 1978, or during any year which commences at five year intervals thereafter, those being the years for periodic review of the Treaty, as provided in Article XIV of the Treaty. This right may be exercised only once.

2. Accordingly, in the event of such notice, the United States would have the right to dismantle or destroy the ABM system and its components in the deployment area of ICBM silo launchers and to deploy an ABM system or its components in an area centered on its capital, as permitted by Article III (a) of the Treaty, and the Soviet Union would have the right to dismantle or destroy the ABM system and its components in the area centered on its capital and to deploy an ABM system or its components in an area containing ICBM silo launchers, as permitted by Article III (b) of the Treaty.

3. Dismantling or destruction and deployment of ABM systems or their components and the notification thereof shall be carried out in accordance with Article VIII of the ABM Treaty and procedures agreed to in the standing Consultative Commission.

Article III

The rights and obligations established by the Treaty remain in force and shall be complied with by the Parties except to the extent modified by this Protocol. In particular, the deployment of an ABM system or its components within the area selected shall remain limited by the levels and other requirements established by the Treaty.

Article IV

This Protocol shall be subject to ratification in accordance with the constitutional procedures of each Party. It shall enter into force on the day of the exchange of instruments of ratification and shall thereafter be considered an integral part of the Treaty.

Done at Moscow on July 3, 1974, in duplicate, in the English and Russian languages, both texts being equally authentic.

For the United States of America:

Richard Nixon
President of the United States of America

For the Union of Soviet Socialist Republics:

L. I. Brezhnev
General Secretary of the Central Committee of the CPSU

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